Dust – everyone “gets it”

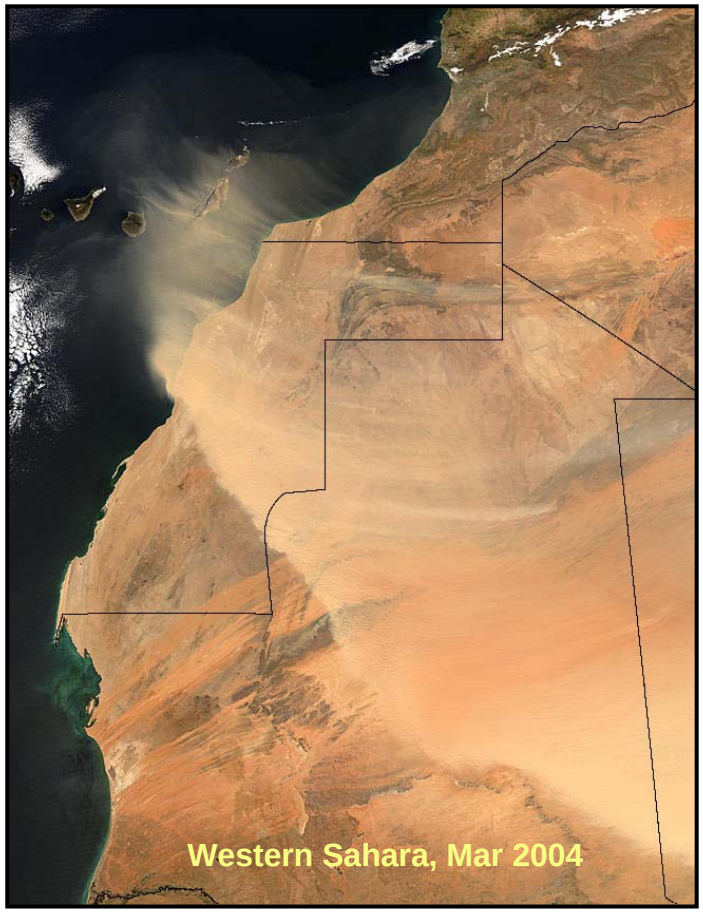
Spectacular images of dust storms convey that wind can move…

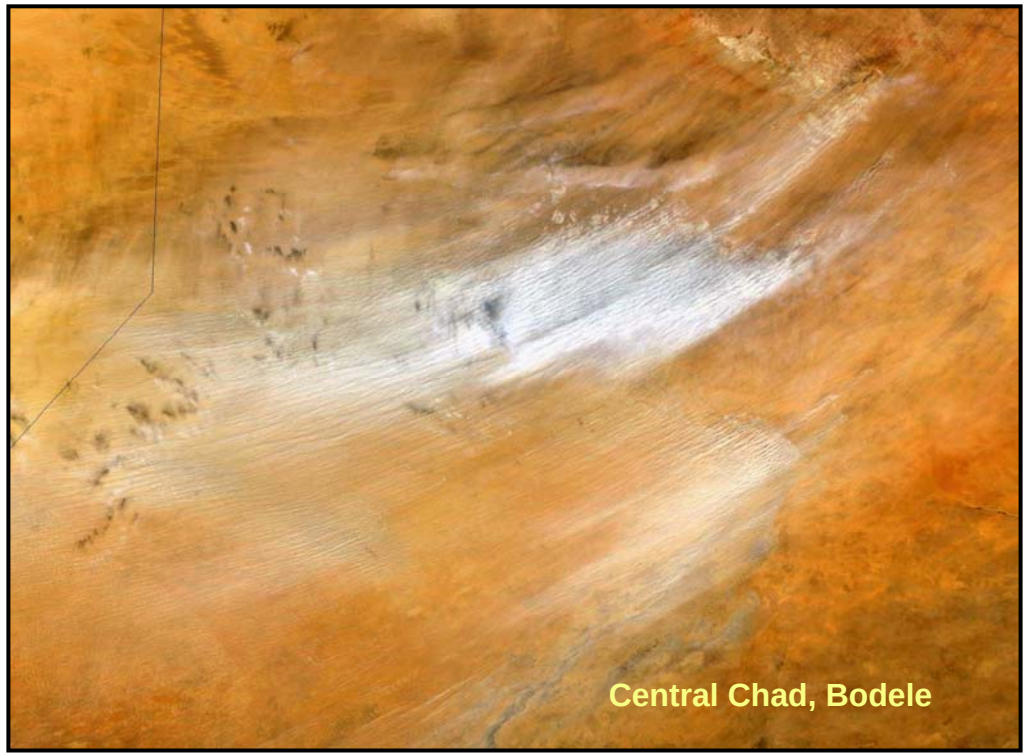
Lots of material

Far

Quickly !

Some North African dust sources





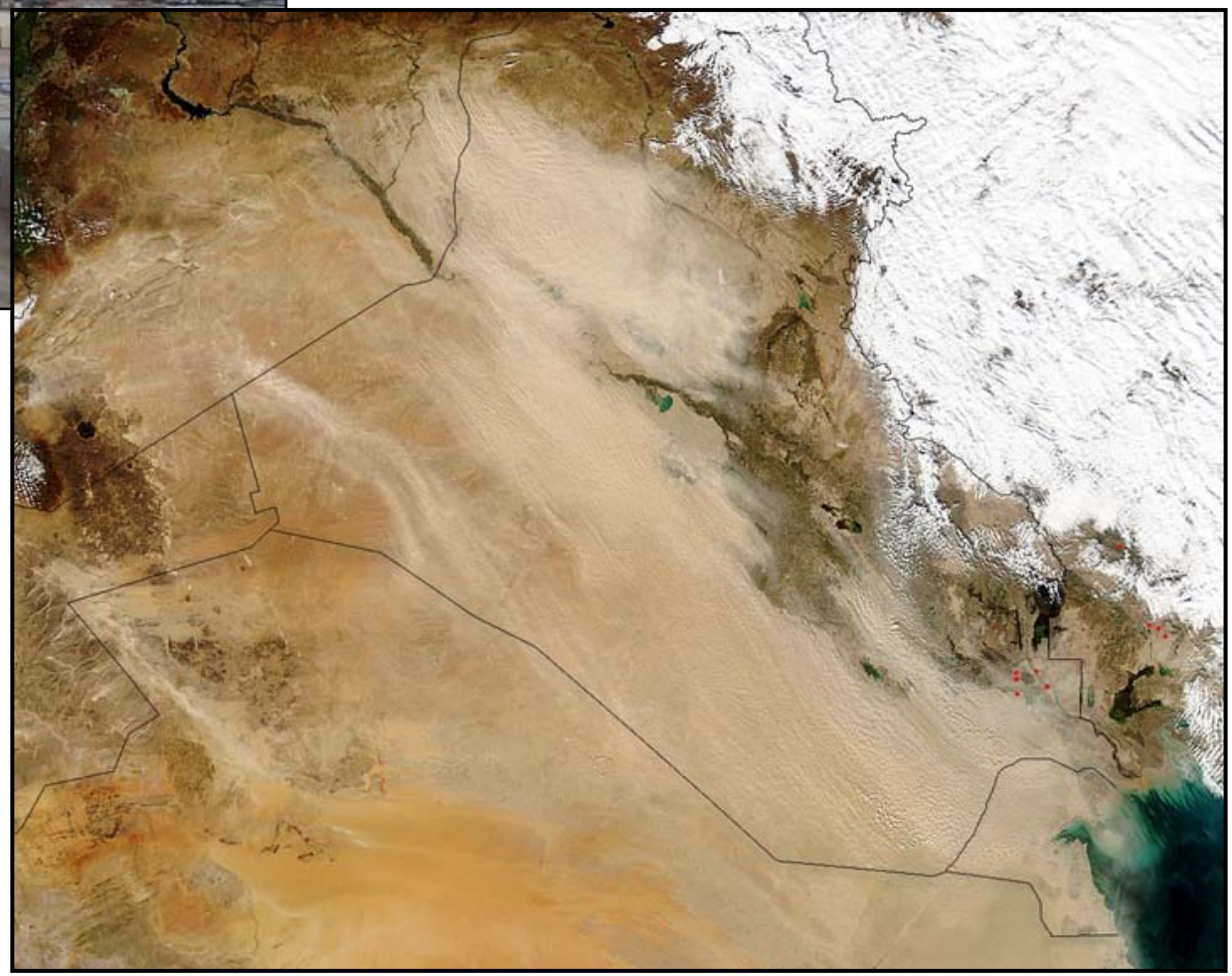
Dust storms originate from many "small" sources

What processes and properties are responsible for "small" sources ?

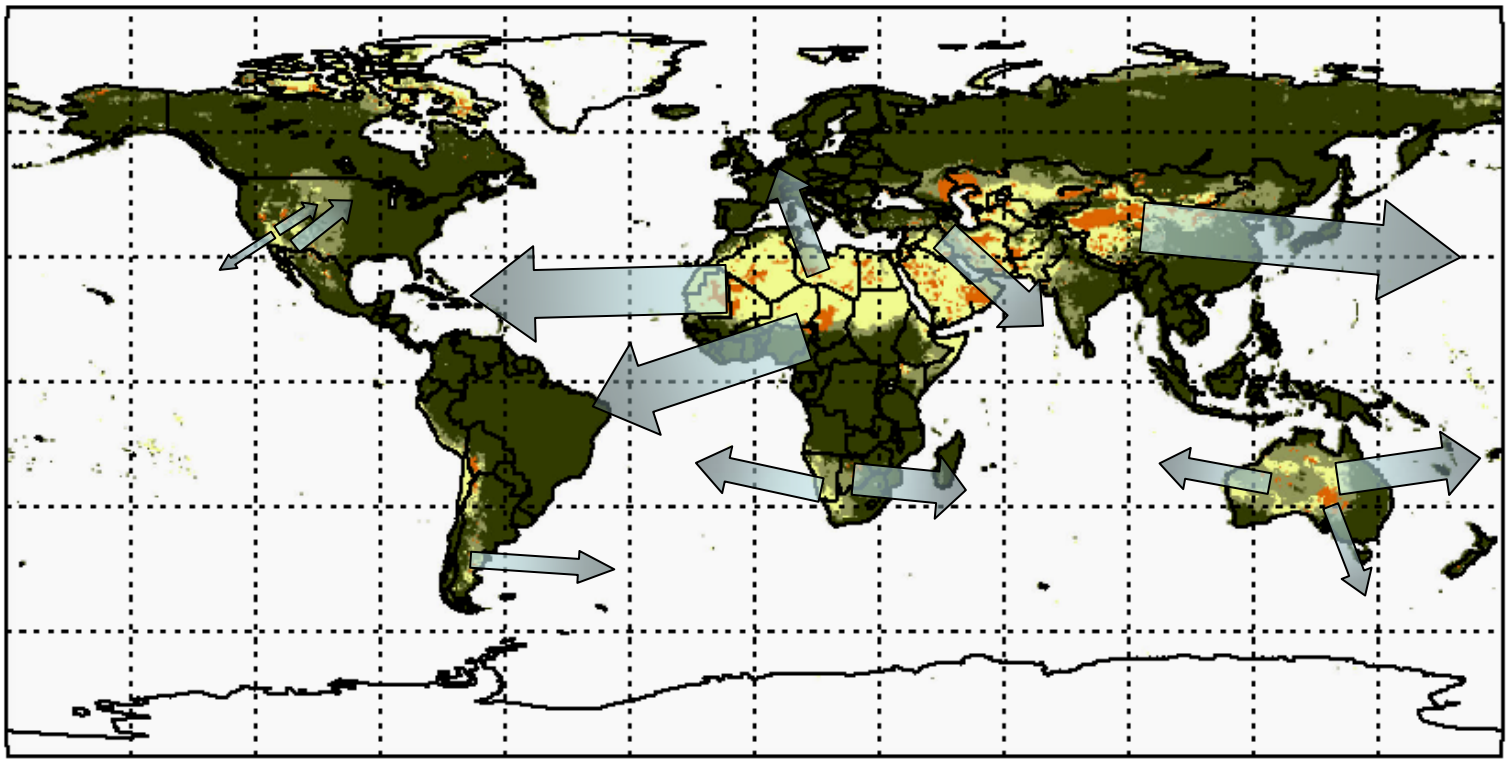
Must consider at the "geomorphic scale" of 1-1000 m

Dust storm in Iraq

Feb. 2006



Dust source areas in the BGC-Jena model



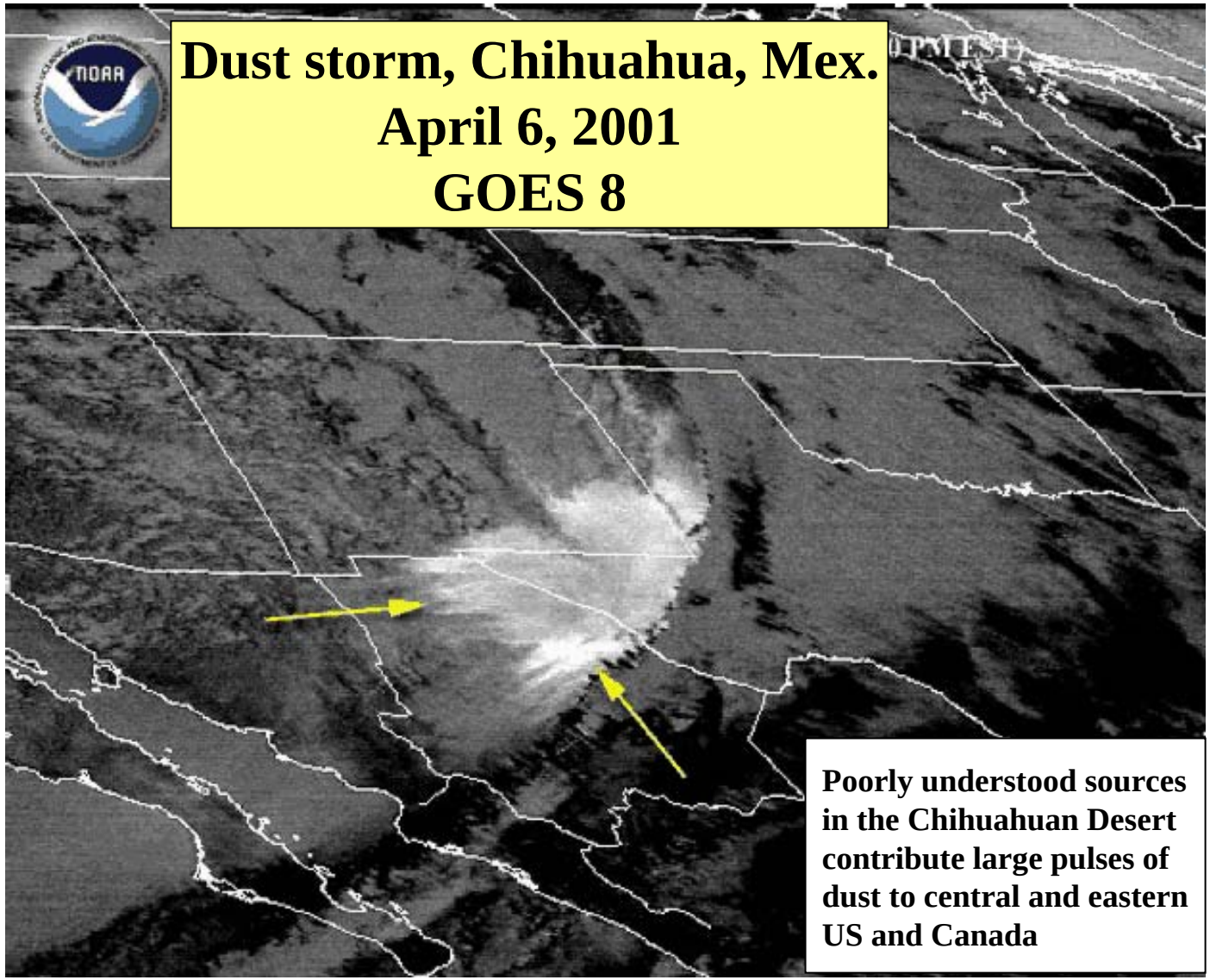
Annual dust sources

Seasonal dust sources

No dust emission

Preferential source

Harrison, Kohfeld, Tegen


Dust storm, Chihuahua, Mex.
April 6, 2001
GOES 8
Poorly understood sources in the Chihuahuan Desert contribute large pulses of dust to central and eastern US and Canada

Why study North American dust?

Landscape changes—past, present, future

Ecosystem dynamics (land management issues)

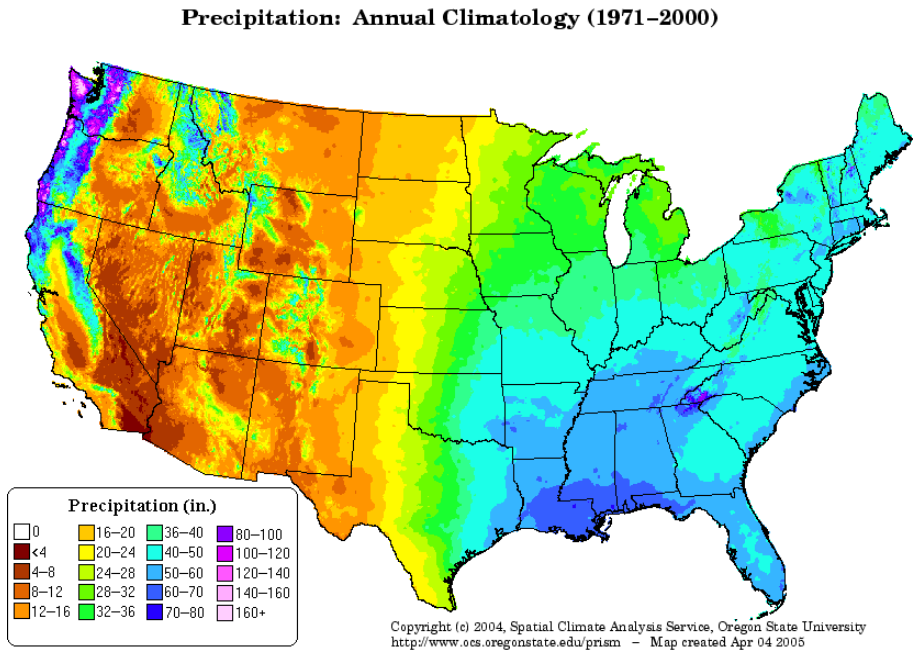
- wind erosion and loss of soil nutrients
- nutrient gains elsewhere

Visibility -- for protected air quality and transportation hazards

Health

Climate effects?

Develop understanding for global applications



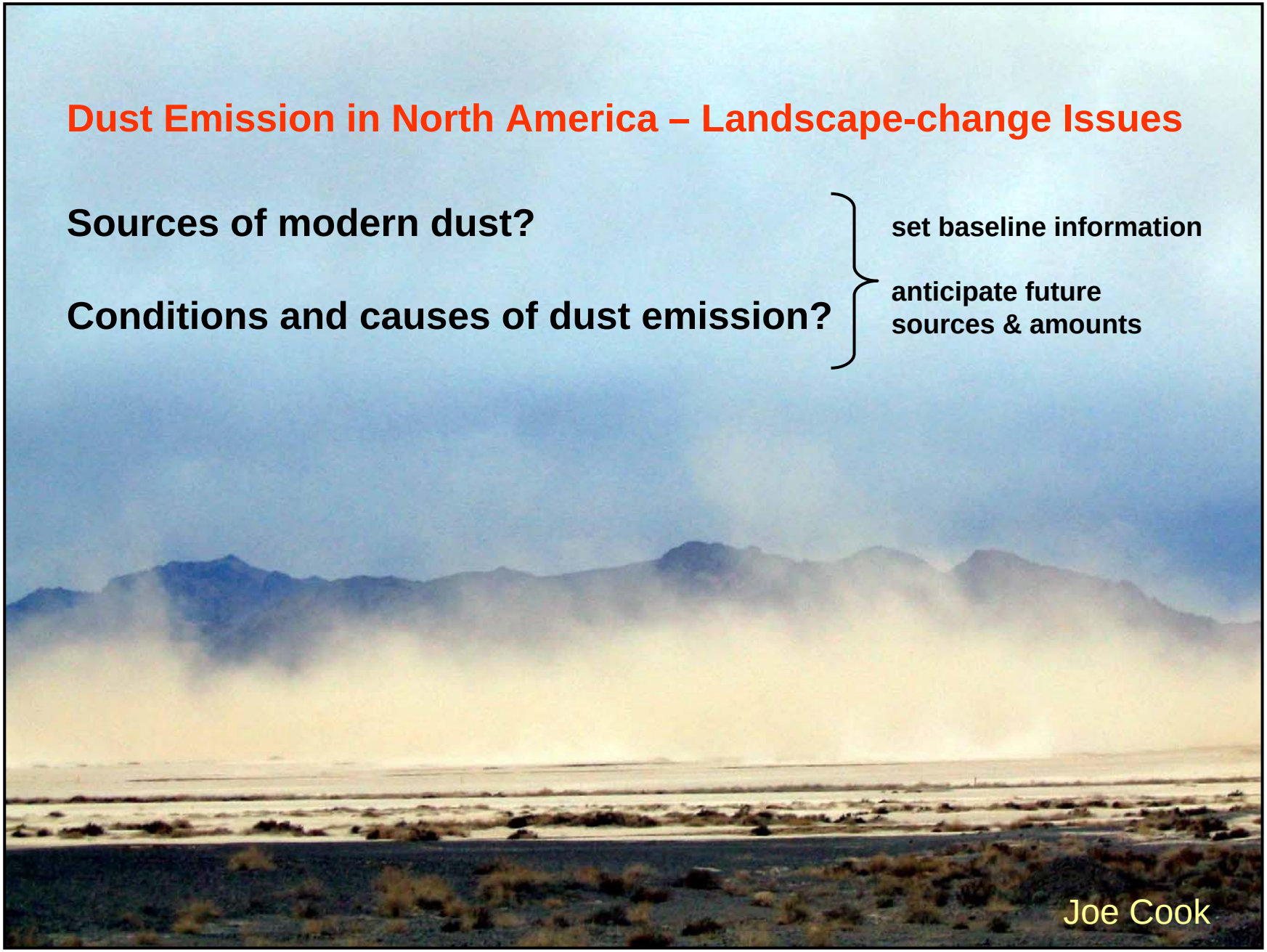
Dust Emission in North America – Landscape-change Issues

Sources of modern dust?

Conditions and causes of dust emission?

set baseline information

anticipate future sources & amounts



Dust Emission in North America

Dust emission from vegetated terrain

Conditions and controls -- vegetation dynamics, amount & timing of precipitation, biologic & physical soil crusts

Dust emission from playas

Conditions and controls—ground water and surface water, crusts & mineralogy

Effects of human activity on recent & modern dust?

new sources?
changes in amounts?
changes in composition?

Dust Emission in American drylands

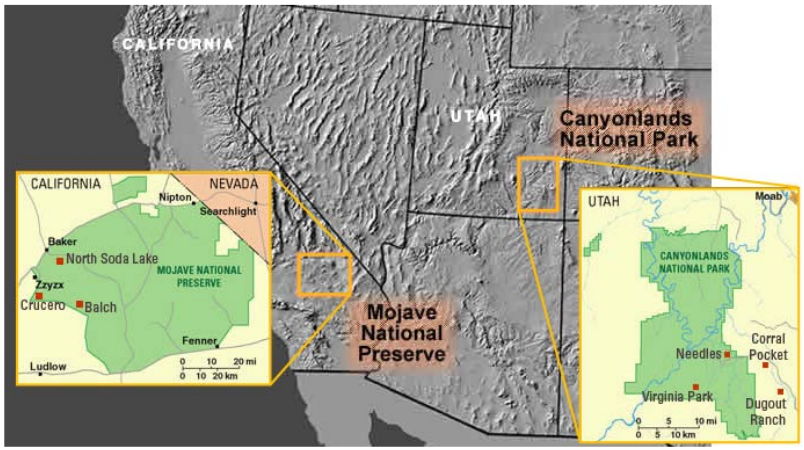
Interannual Variations Controlled by:

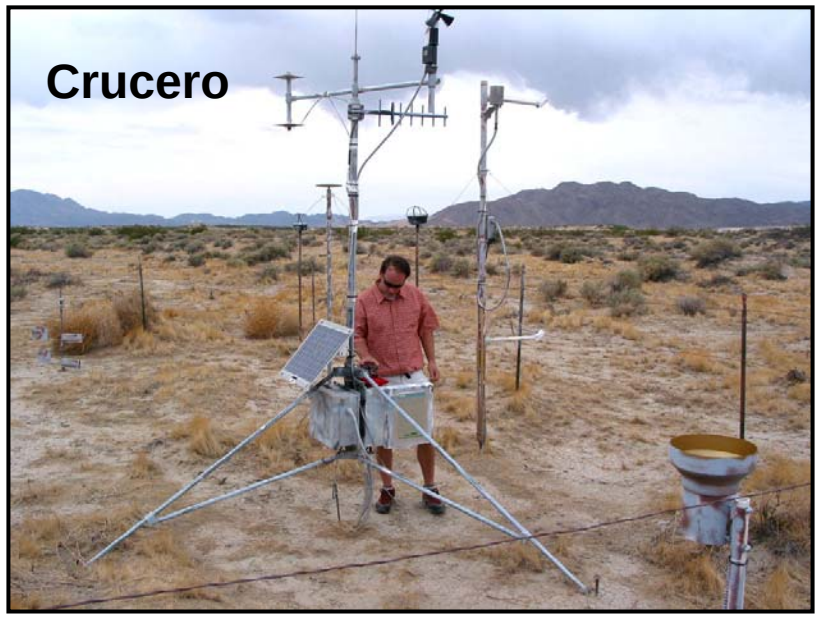
- Antecedent precipitation (amount and timing)
- Vegetation dynamics (perennials and annuals)
- Sediment sources (natural & land-use factors; flooding)
- Wind-storm frequency & strength
  (climatic controls on flow patterns)

Southwest Climate Impact Meteorological Stations (CLIM-MET)

Instrumentation Details | Learn more about USGS CLIM-MET Stations | View repeat photography of the stations

For data and area description, choose a CLIM-MET station by clicking on a site (red squares) in the map below (or, use the links listed below the map):



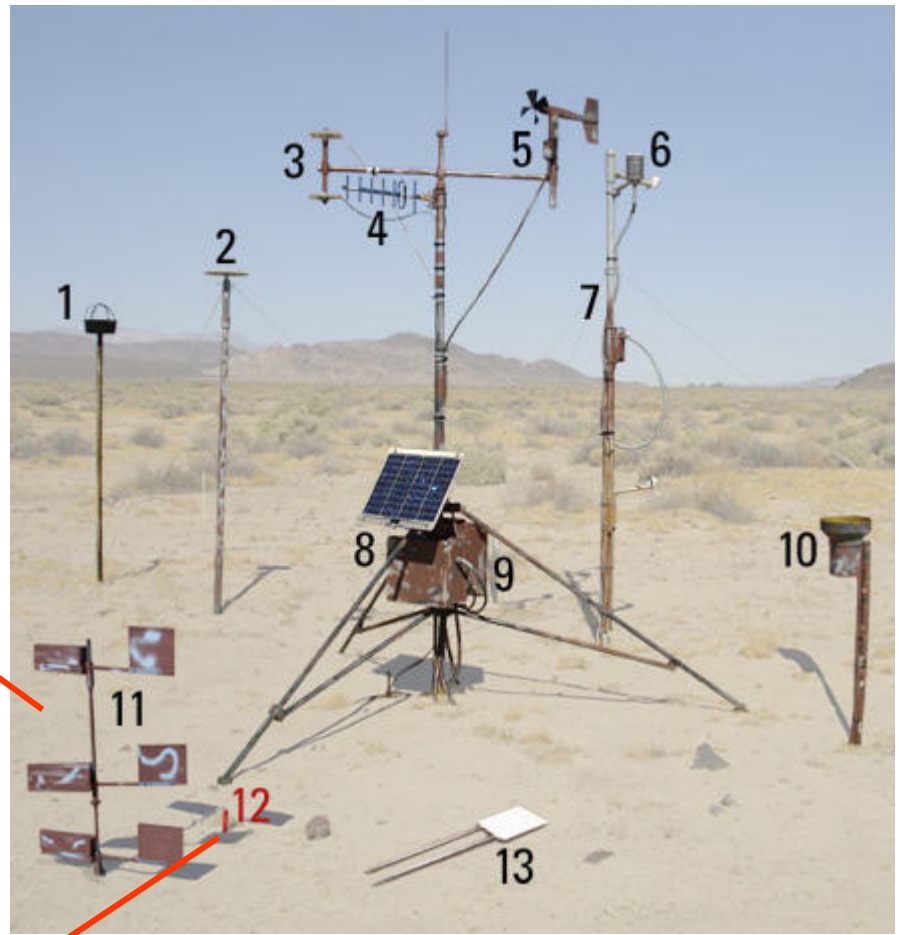


Mojave National Preserve, California:
North Soda Lake
Balch
Crucero

Canyonlands National Park, Utah:
Virginia Park
Needles
Dugout Ranch
Corral Pocket

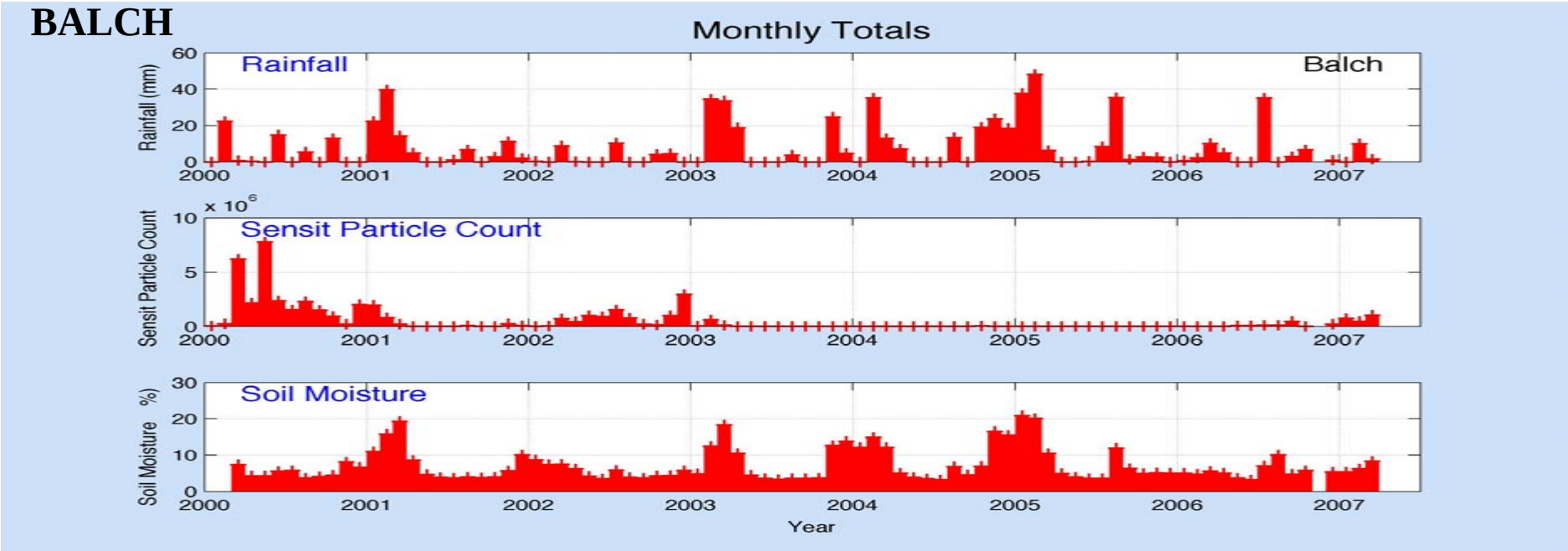
Anatomy of a CLIM-MET Weather Station

“BSNE”



“sensit”

BALCH



04_2000

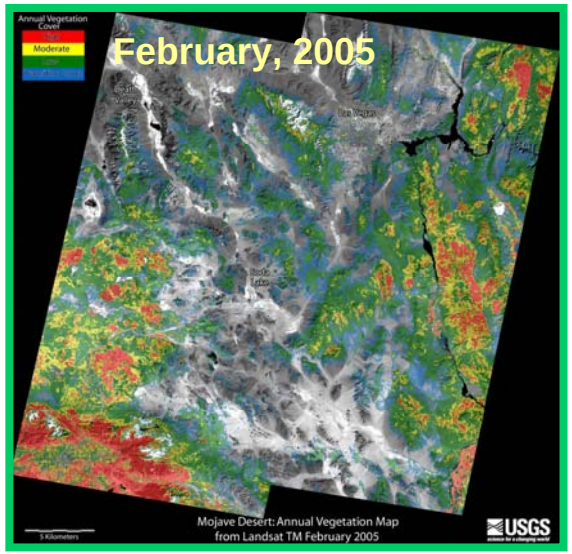
04_2001

04_2002

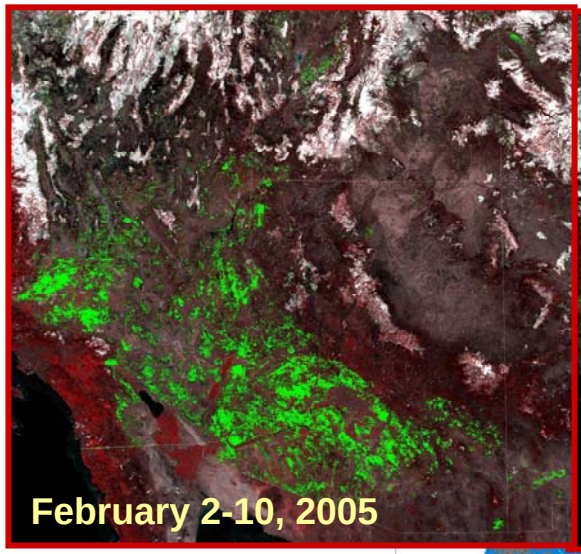
03_2005

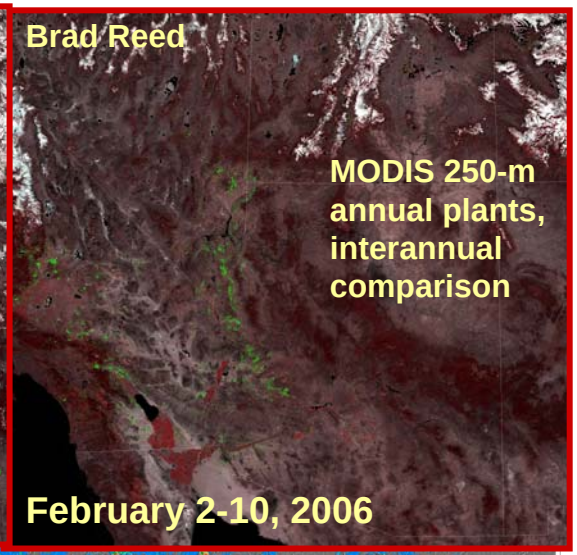
03_2007

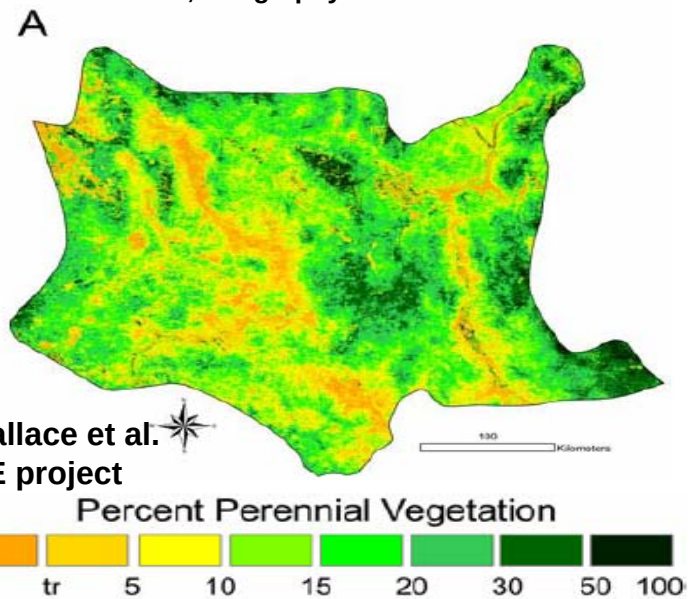
Examples of surfaces that characterize Mojave landscape for wind-erosion studies



Landsat TM 30-m res annual plants
P. Chavez, Geography

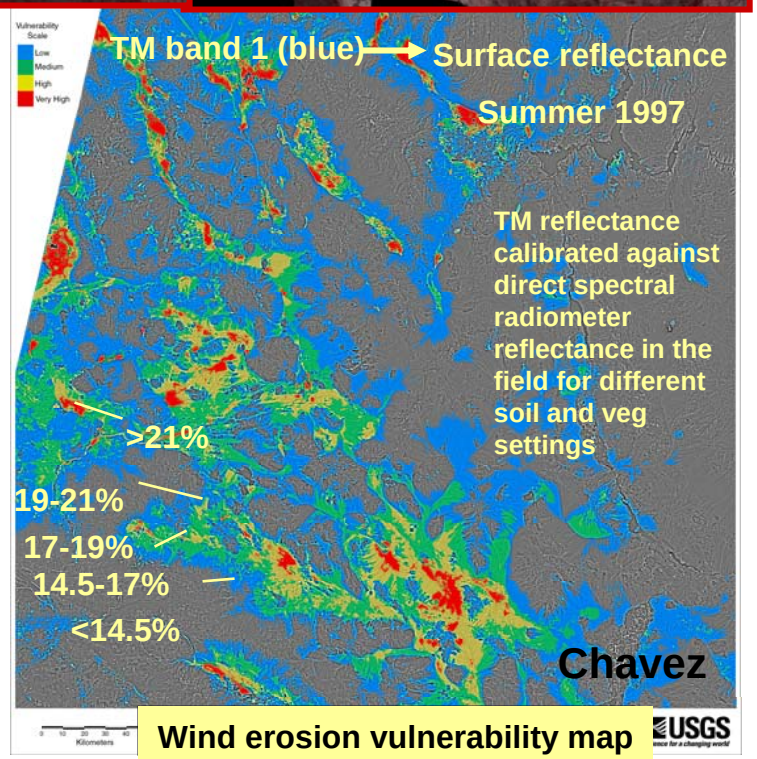






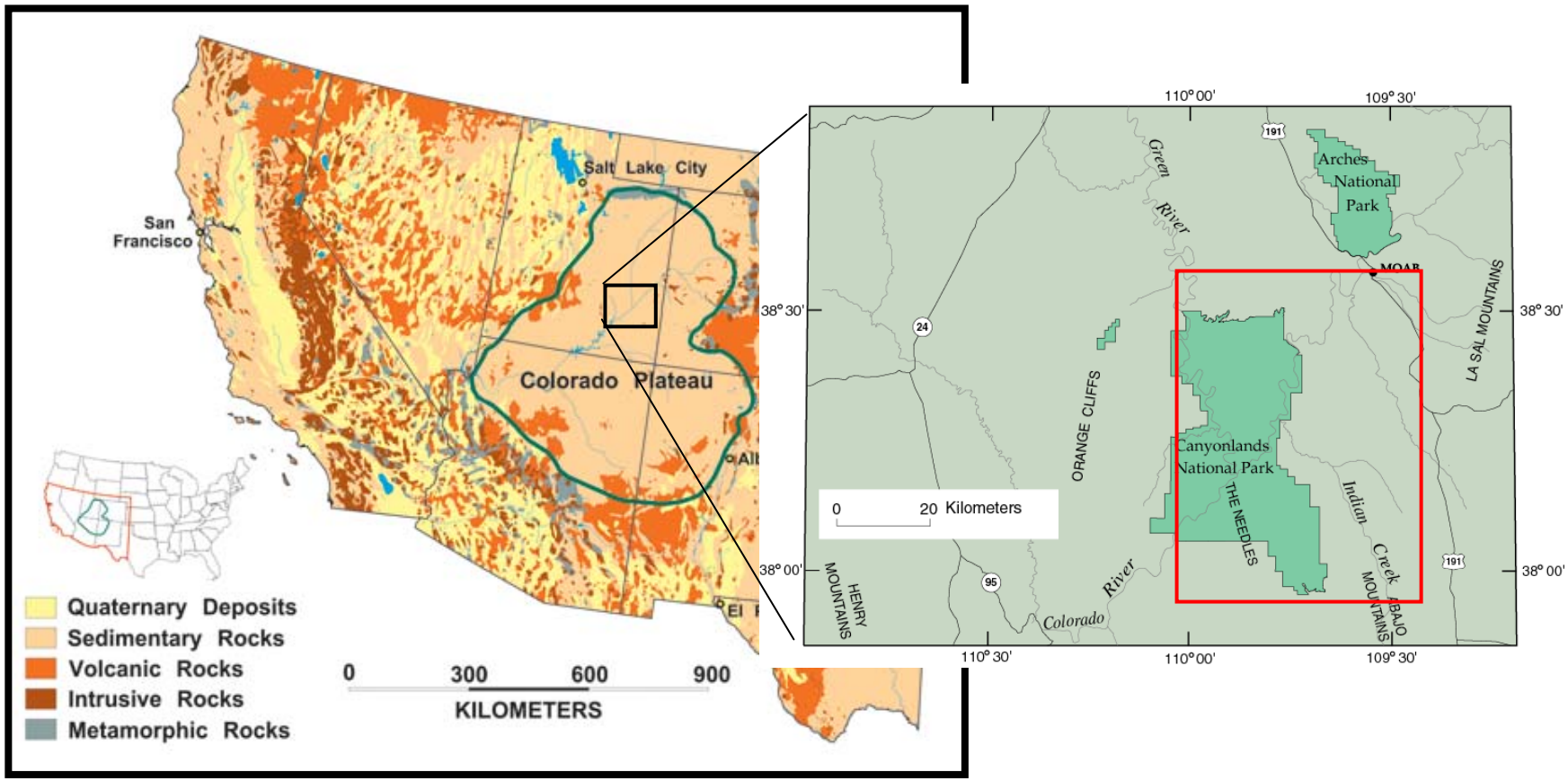
C. Wallace et al.
RVDE project

Mojave perennial veg MODIS-EVI

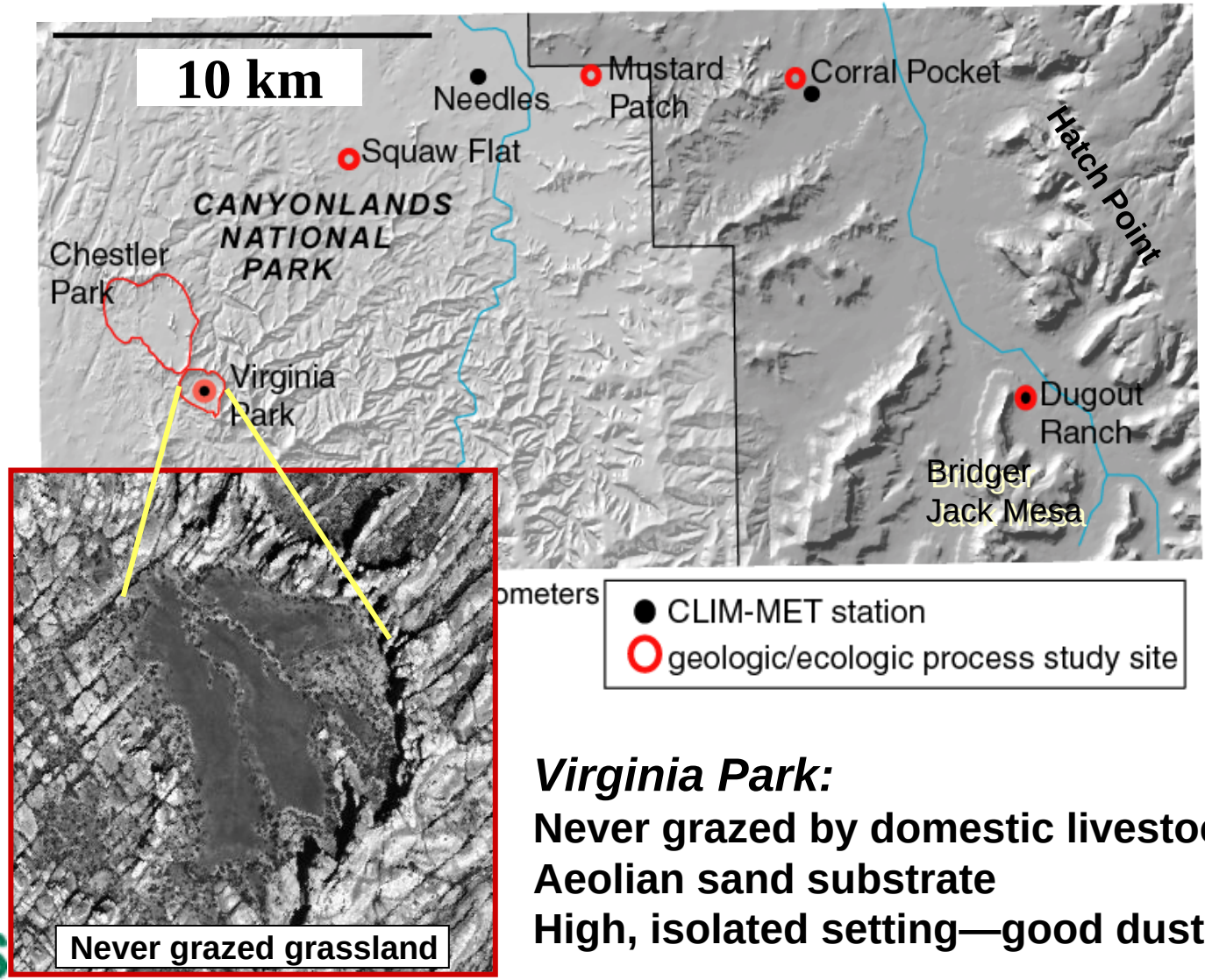


Wind erosion vulnerability map

The central Colorado Plateau—a high, cold desert



USGS



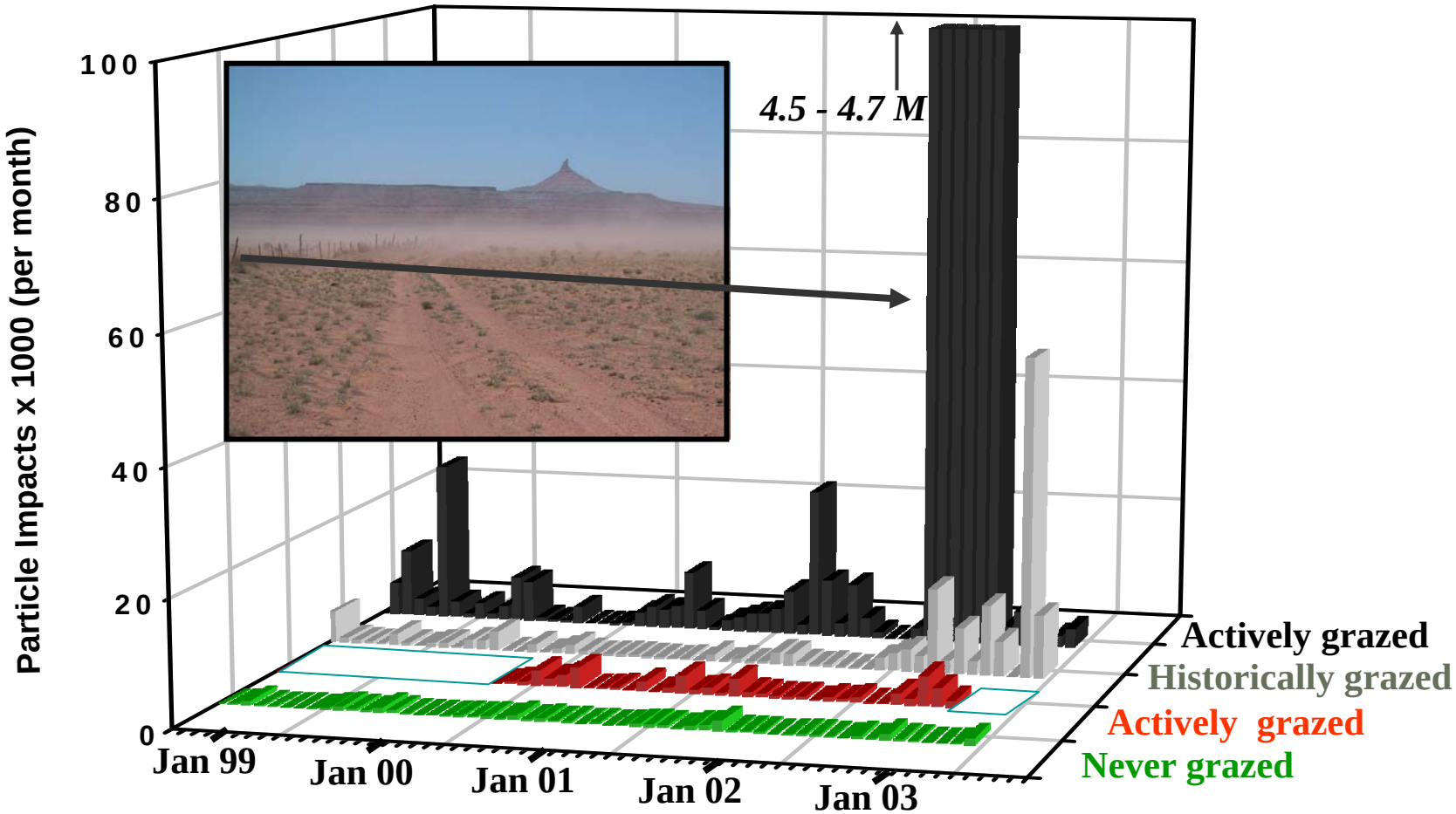
Virginia Park:

Never grazed by domestic livestock

Aeolian sand substrate

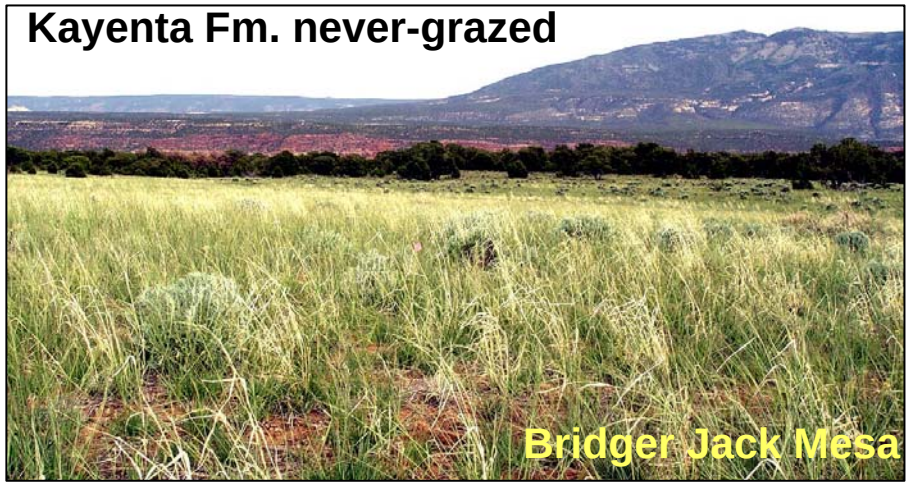
High, isolated setting—good dust trap

Particle movement in saltation layer—
relations to grazing histories



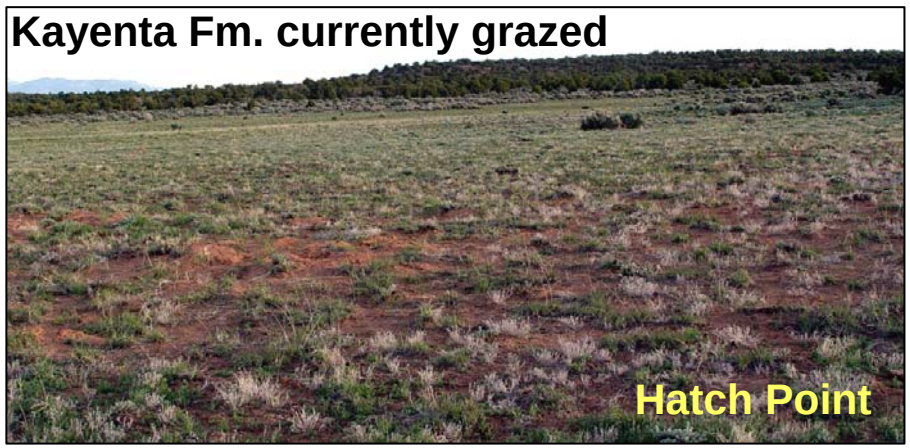
USGS

Differences between never-grazed and currently grazed grasslands



More vegetation cover
More fertile
2x more dust (magnetite)
2x Cation Exchange Capacity

C – 0.66 kg m^{-2}
N – 0.05 kg m^{-2}



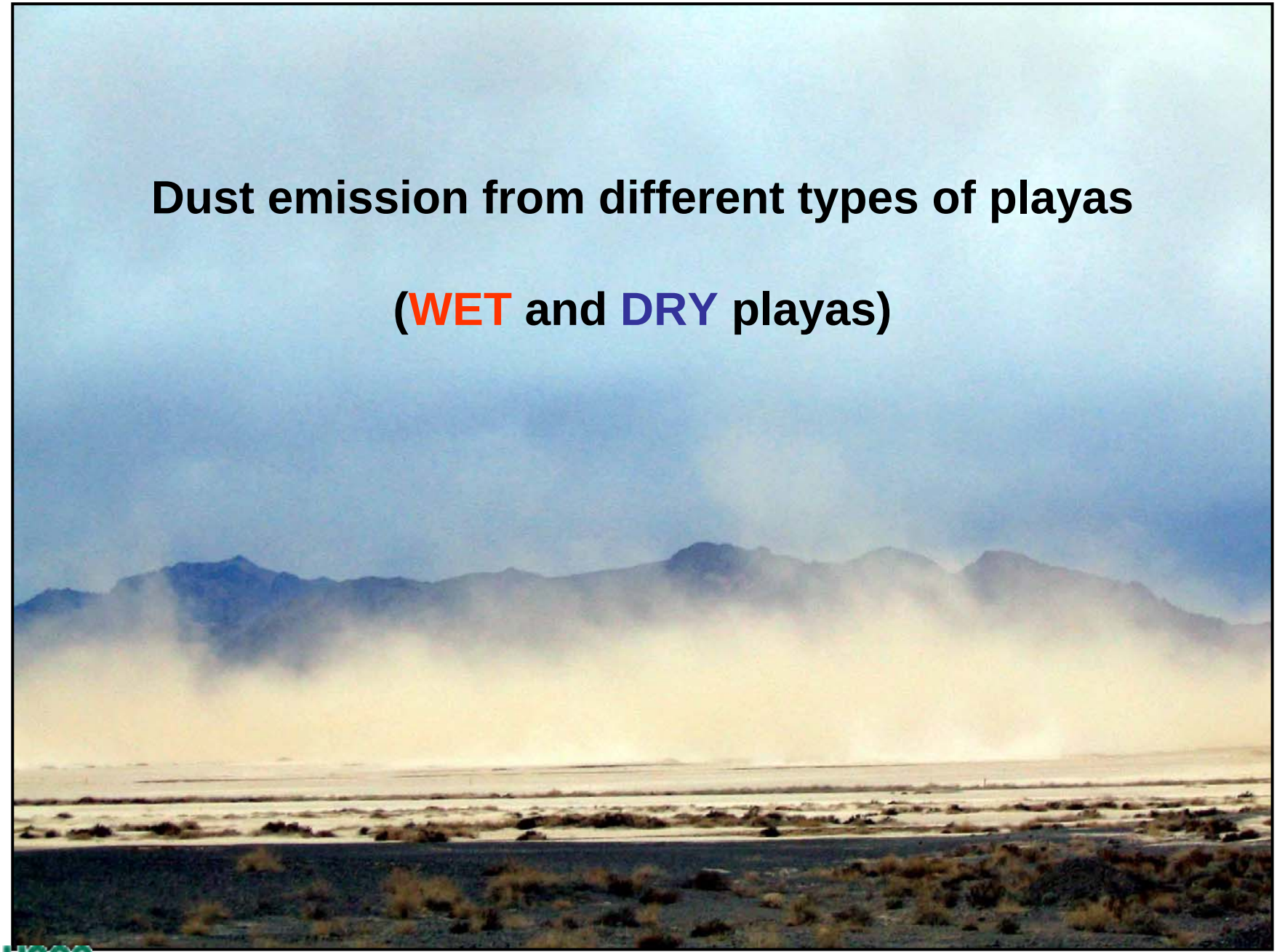
C – 0.22 kg m^{-2}
N – 0.02 kg m^{-2}

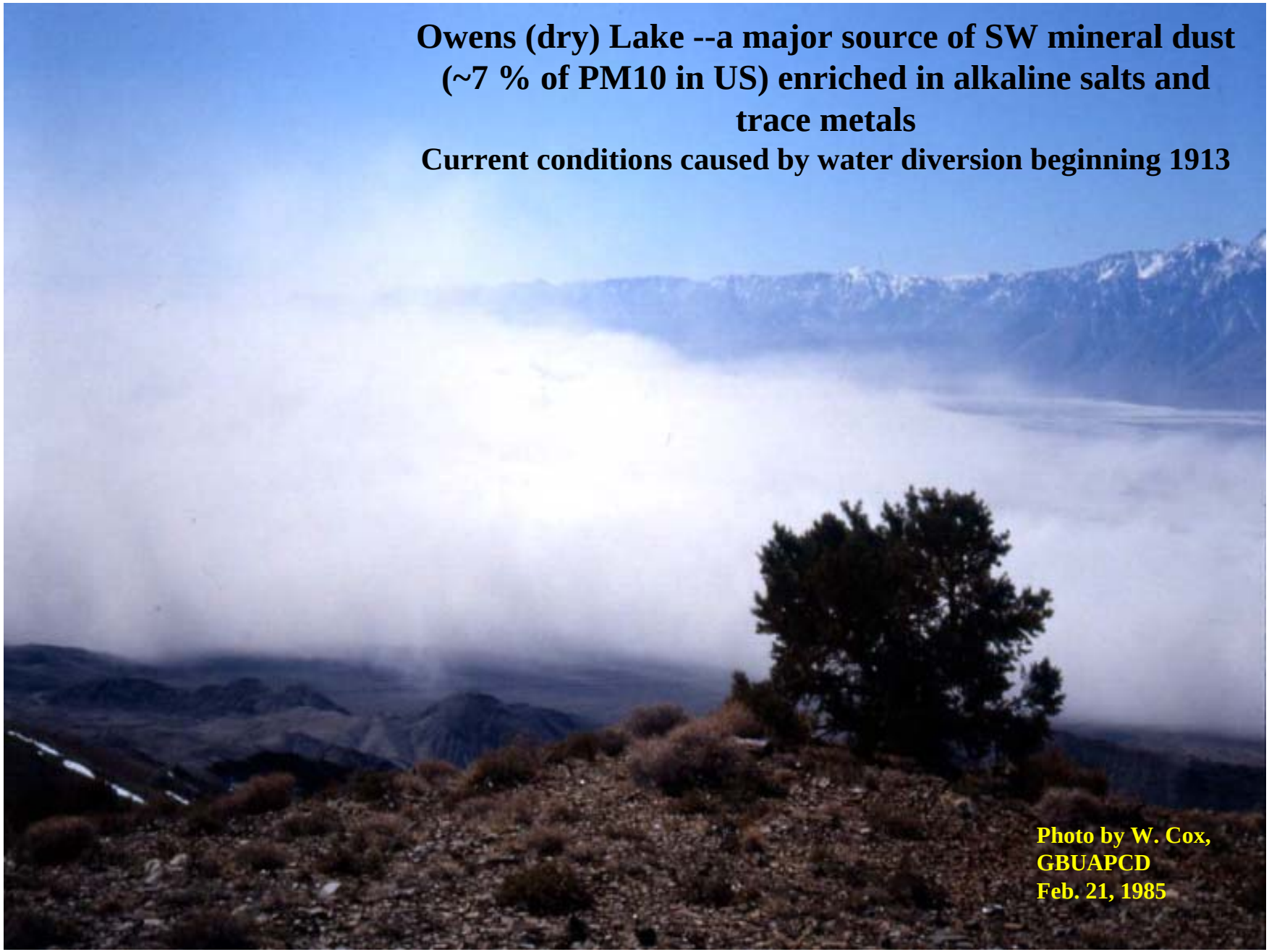
USGS

Dan Fernandez

Dust emission from different types of playas

(WET and DRY playas)




Owens (dry) Lake --a major source of SW mineral dust (~7 % of PM10 in US) enriched in alkaline salts and trace metals
Current conditions caused by water diversion beginning 1913
Photo by W. Cox, GBUAPCD
Feb. 21, 1985

Relevance

Wet-playa dust differs from dry-playa dust (composition, size, shape, and color):

Different radiative properties

Different compositions of chemical and clastic dusts may affect atmospheric chemistry in different ways

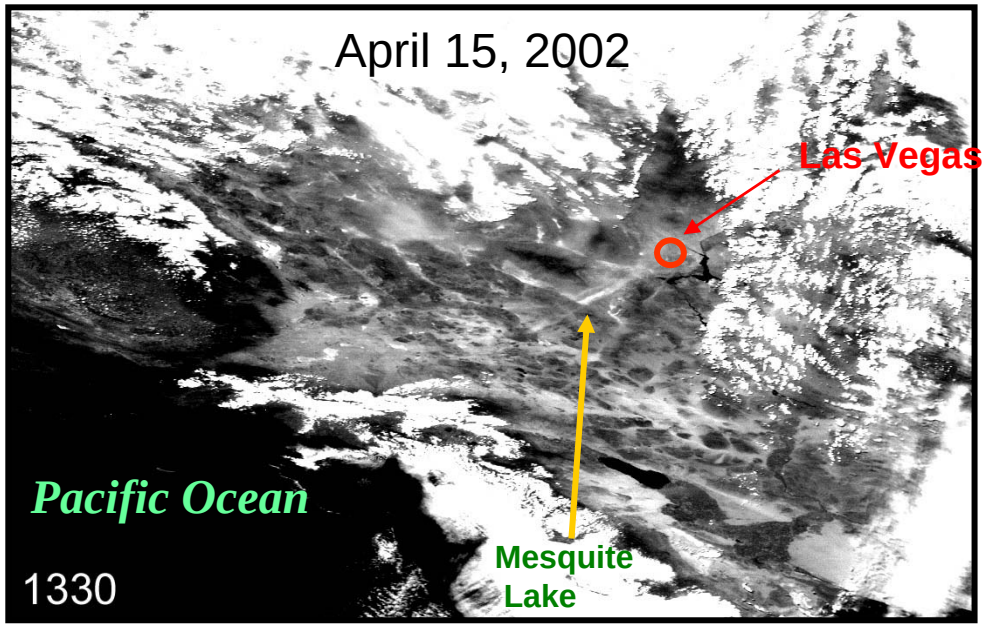
Different playa dusts will likely have variable effects on:

Marine and terrestrial ecosystems

Human health

USGS

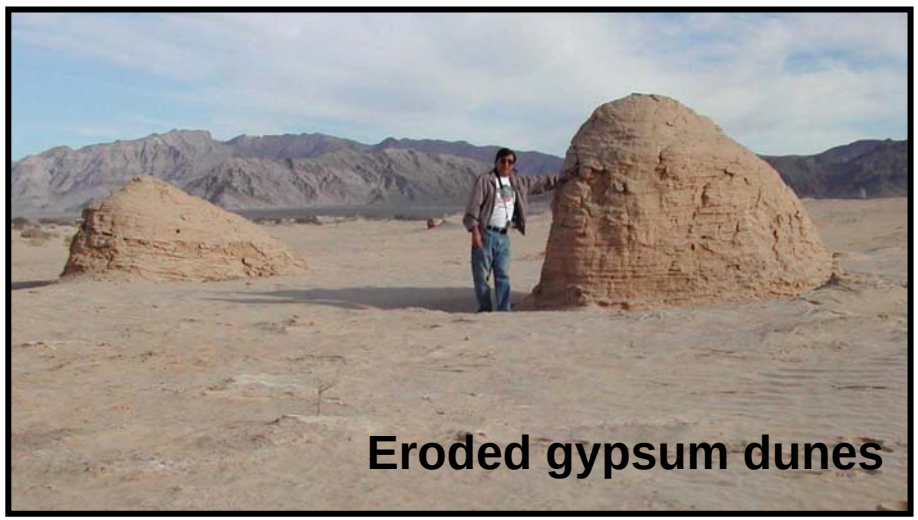
History of recent wind erosion and dust emission from Mesquite Lake playa

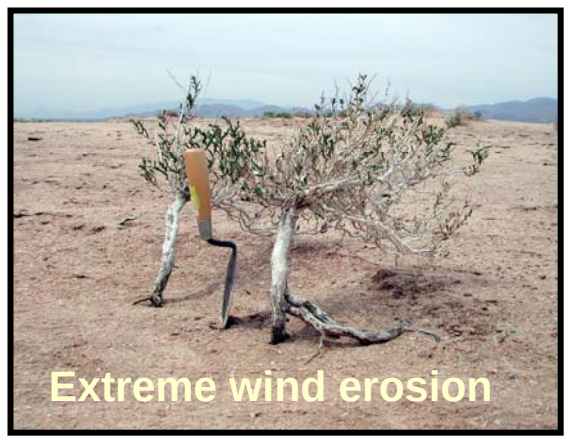


Conversion of wet playa to dry playa since 1960s
--by ground-water withdrawals ?

Massive decrease in ground water levels since 1960s

Extreme deflation during past five years

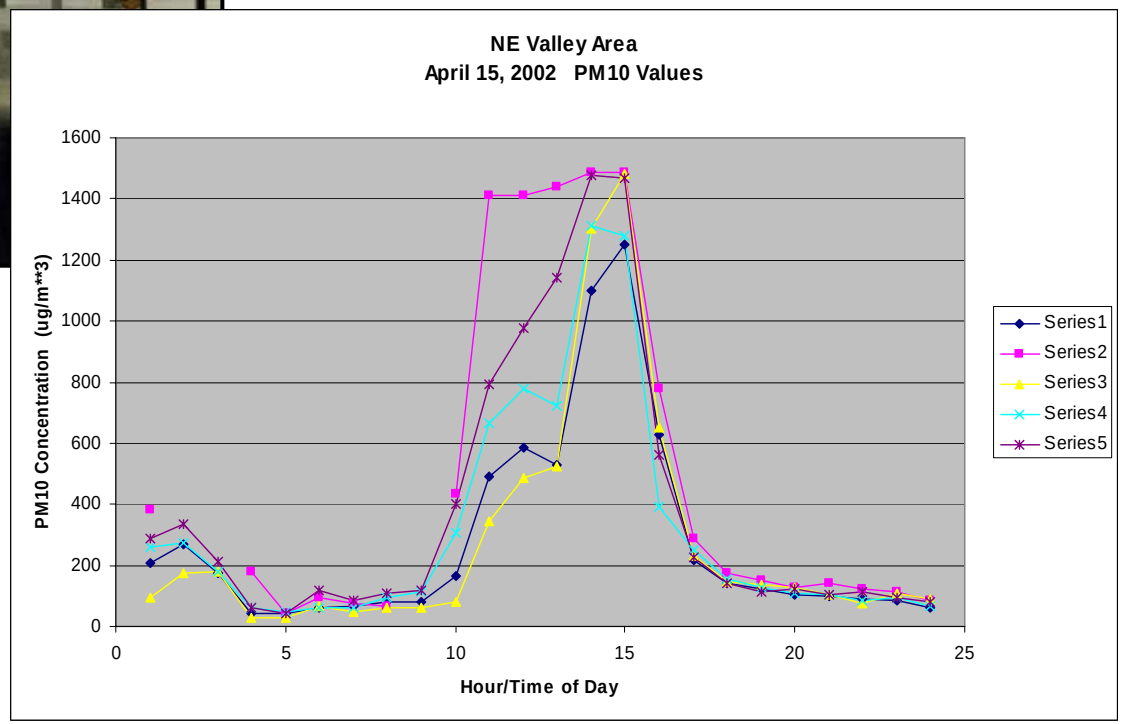




USGS

Las Vegas dust storm April 15, 2002

PM10 values, NE Valley area



Dust in Las Vegas. April 15, 2002

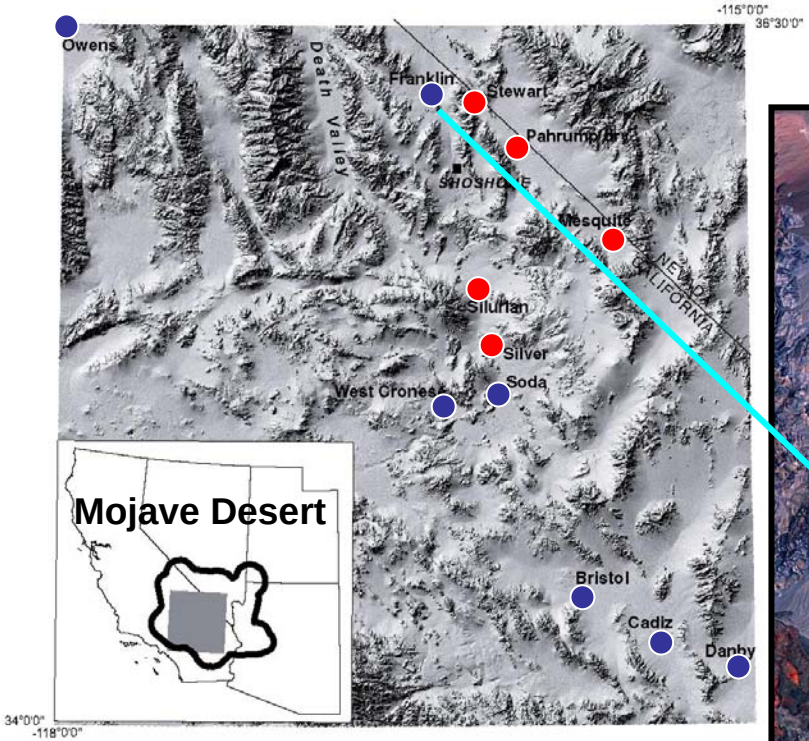
Windstorm was the strongest and most widespread in a decade.

Unhealthy levels of PM10 dust were reported at monitoring stations.

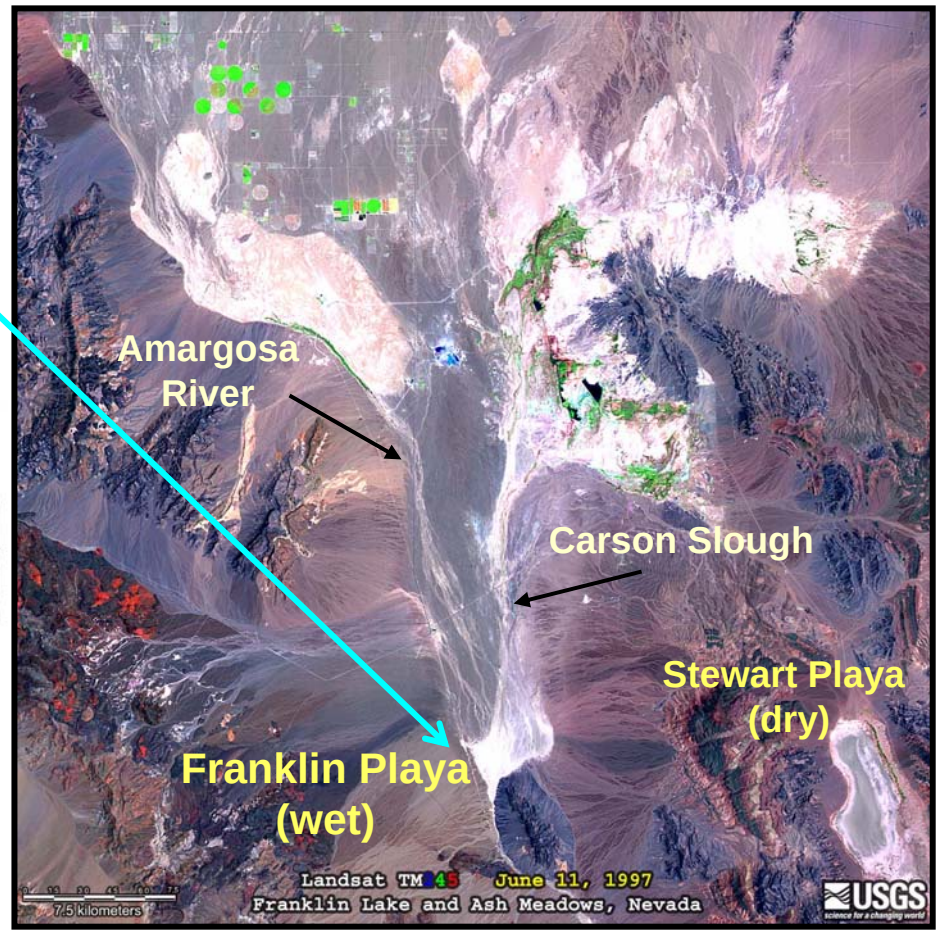
Next step: examine hospital records for mortality

USGS

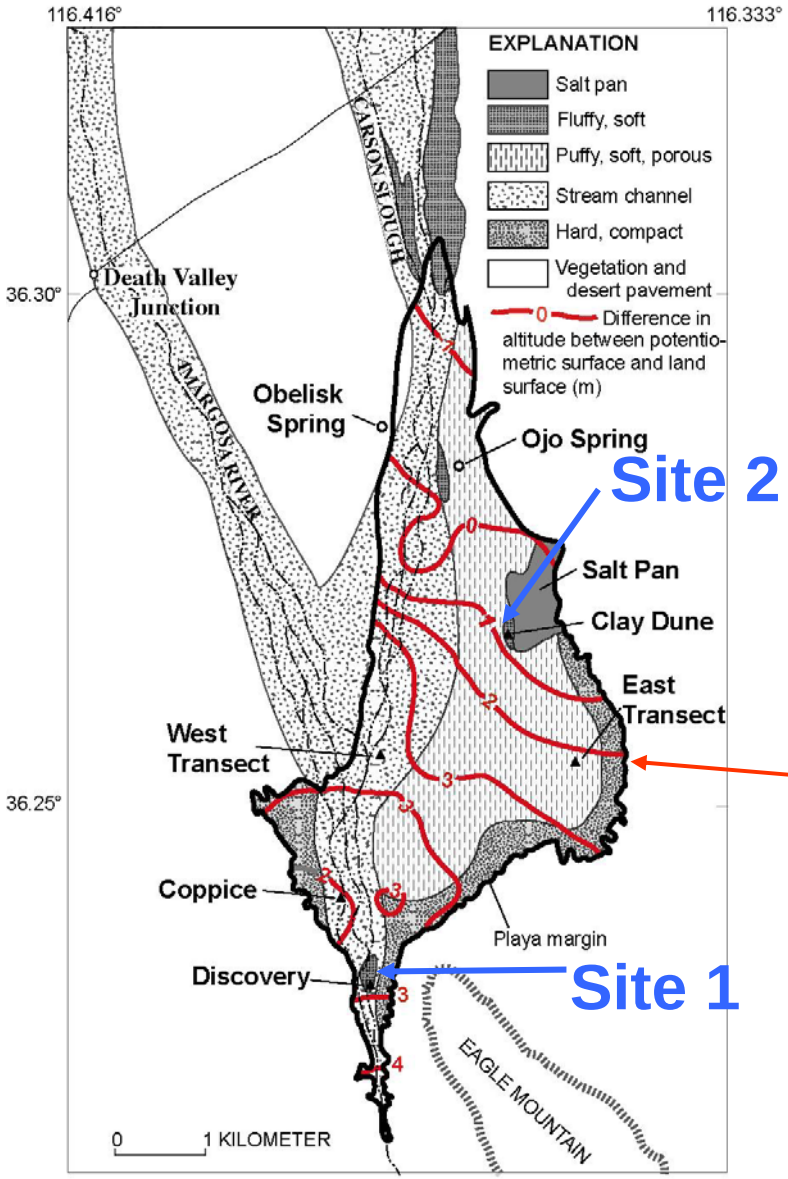
Field studies & monitoring at Franklin Playa (wet playa)



- Wet playa
- Dry playa



Geology and hydrology of Franklin Playa



Surfaces at Franklin Lake playa

Vapor discharge:
13 M m^3 yr^{-1}

Difference in altitude between potentiometric surface and land surface

Czarnecki, J.B., 1997. USGS Water Supply Paper, 2377.

Franklin Playa

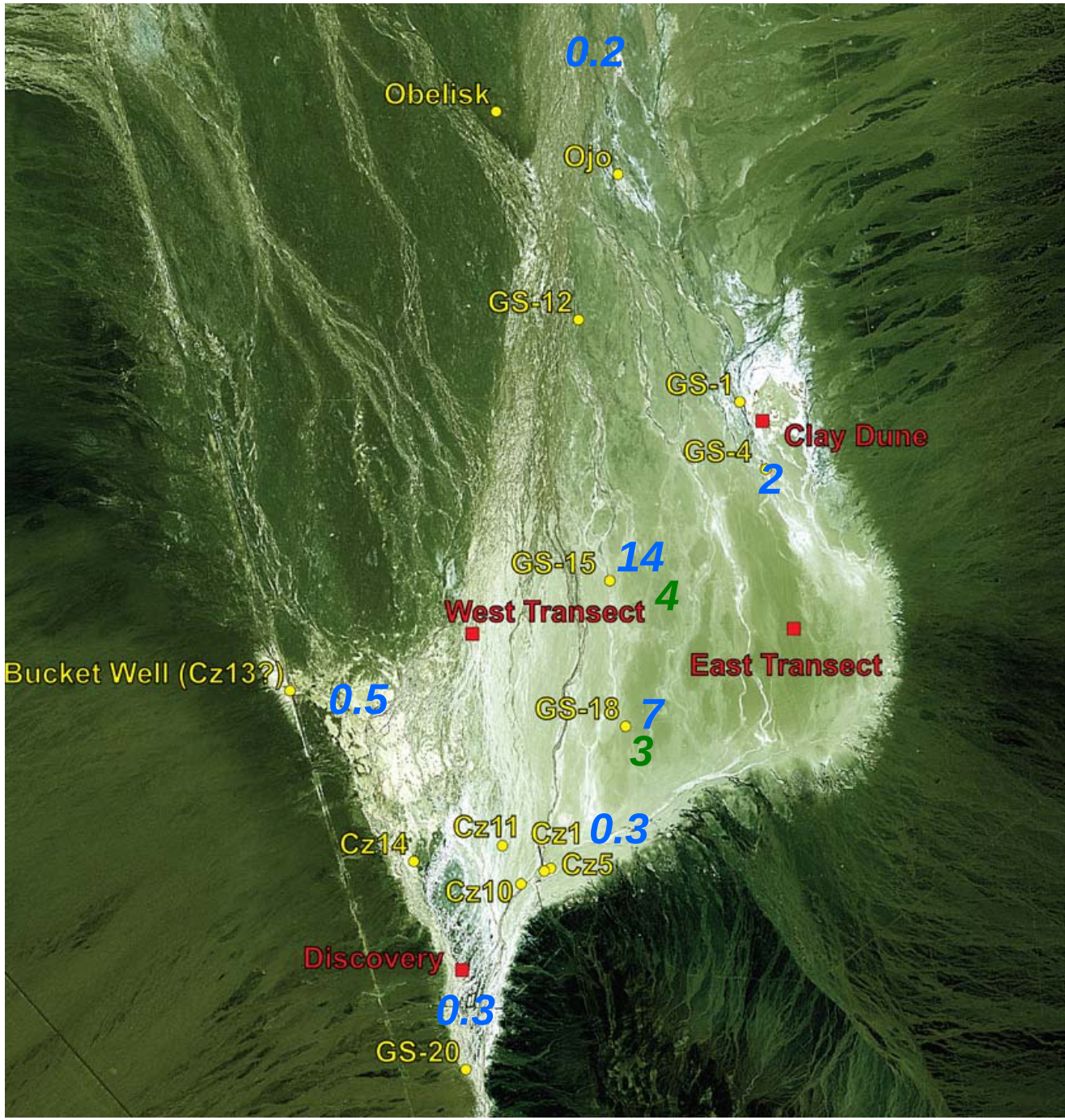
Arsenic (mg/L)
20-1400x of MCL

Uranium (mg/L)
To 130x of MCL

Mineral dusts from wet playas:

Enriched in elements derived from evaporation of alkaline lake water and shallow groundwater (Na, Mg, Sr, Li, B)

Contain elevated As, Cr, Cu, Mo, Ni, Pb, Sb, Th, U, Se
(in trona, thenardite, burkeite, halite)



Franklin Playa:

Chemical Characteristics of Saline Water

		GS-15	USEPA	GS-15/Seawater
S.C.	(mS/cm)	**90**		**1.8**
As	(mg/L)	**14.4**	**0.01***	**12,000**
Cd	(μg/L)	**20**	**5***	**300**
Mo	(mg/L)	**14.6**	**0.18**	**1,500**
Se	(mg/L)	**0.6**	**0.05***	**3,900**
Tl	(μg/L)	**3**	**1***	**230**
U	(mg/L)	**4.3**	**0.03***	**1,300**

* - Maximum Contaminant Level

Field tests for vulnerability of surfaces to wind erosion

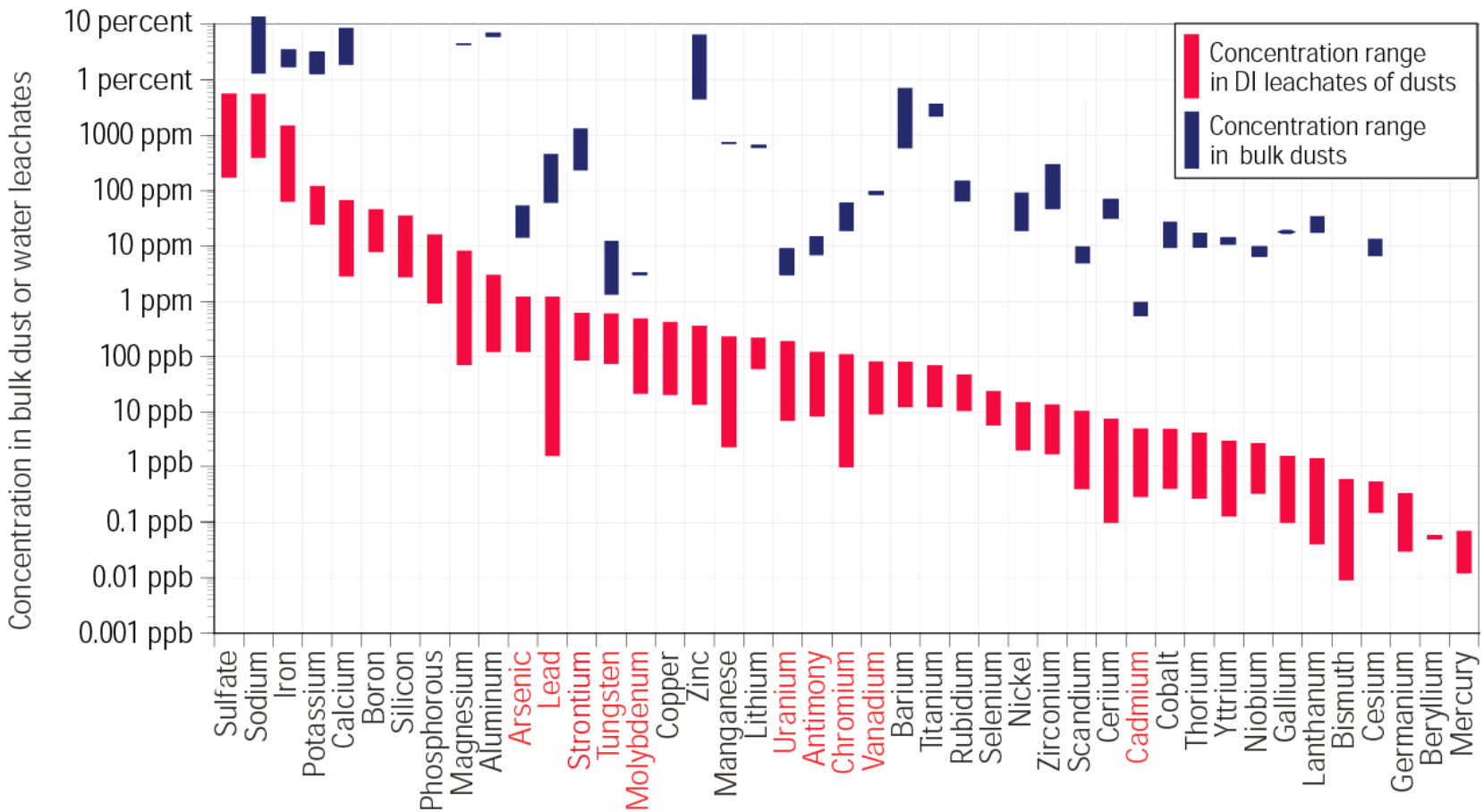
Using portable wind devices to sample dust

Health effects of dust from Owens (dry) Lake

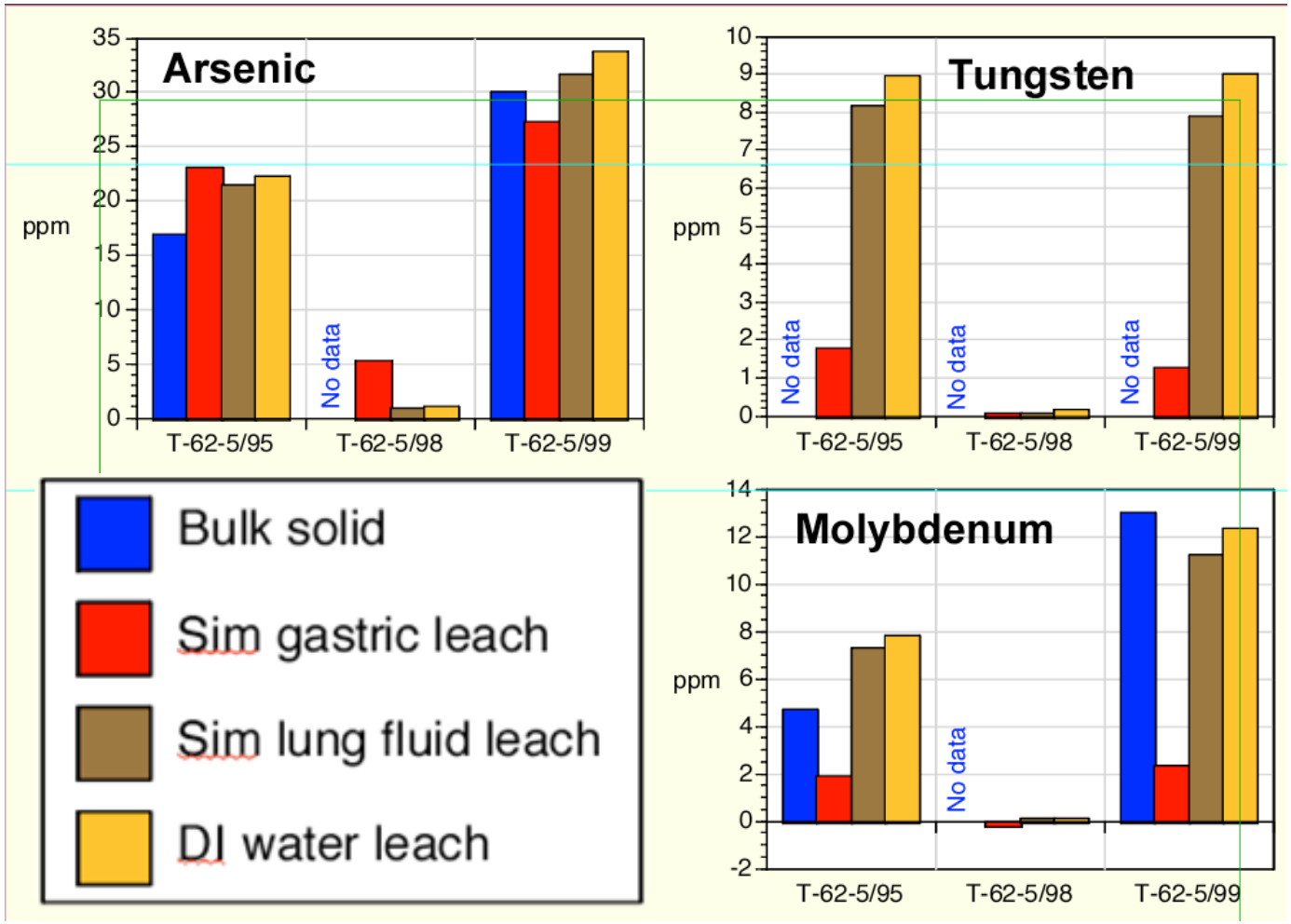
with Geoff Plumlee

Many heavy metals readily released from dust into leachate water, especially elements that form alkaline-mobile oxyanion or carbonate species in solution (W, Mo, As, Pb, U, Sb, Cr, V)

Most readily soluble heavy metals are in soluble alkaline, carbonate, sulfate salts



Toxicants in dry lake beds?



Samples from dust traps around Owens Lake

Simulated bio-fluids leach: Gastric, gastro-intestinal, macrofage phagolysosomal, cell-line carriers

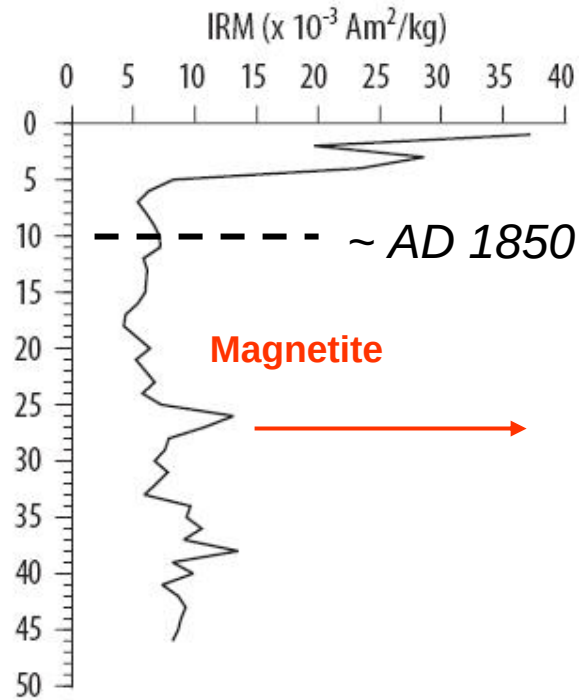
Metals / metalloids taken up by efflorescent salts are stored in soluble, bioaccessible form

Human activities and factors that generate dust

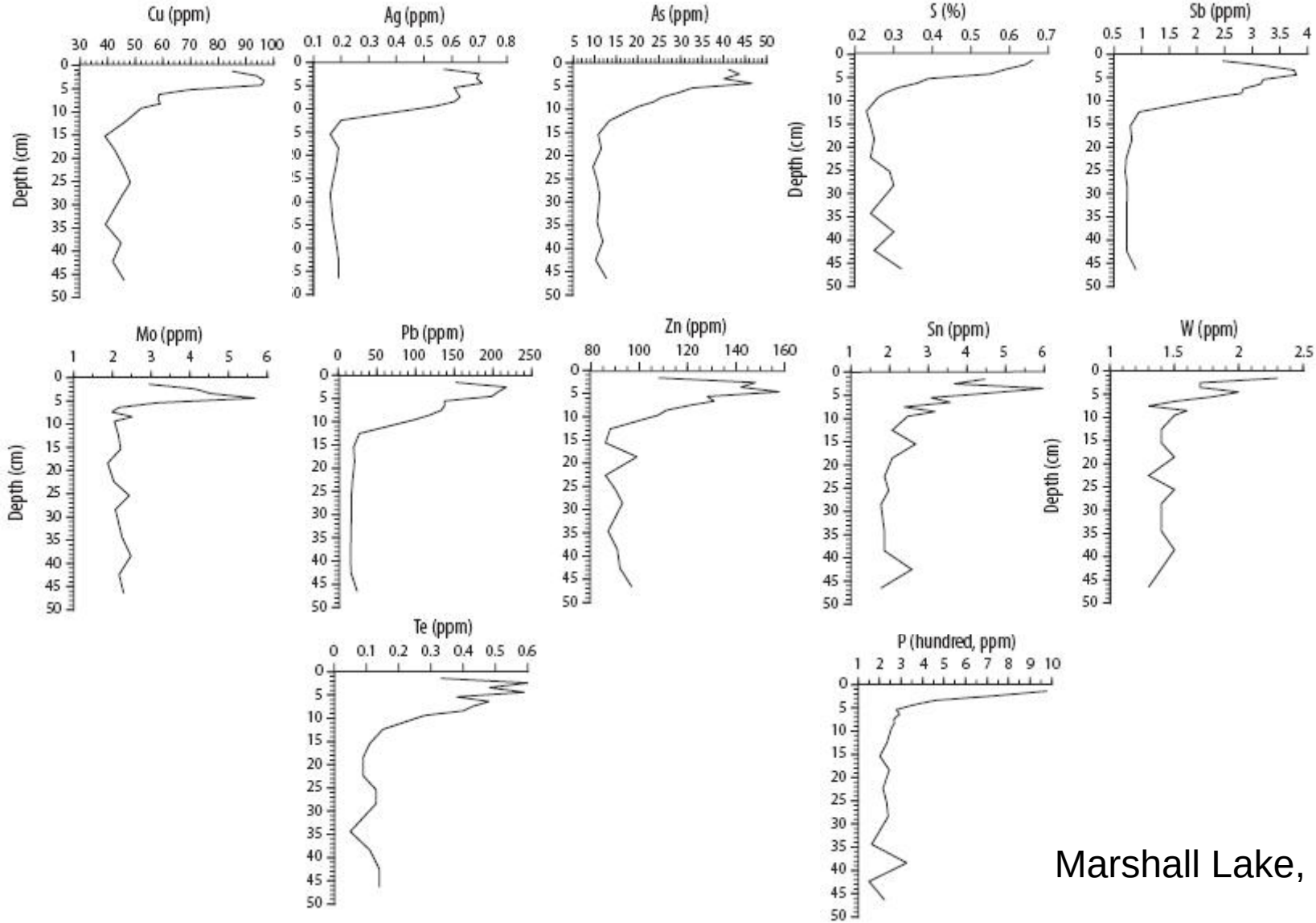
Agriculture (tilling and grazing)
Mining & milling
Desiccation of lakes
Power generation by fossil fuel combustion (e.g., fly ash)
Urbanization
Transportation
Recreation
Military activities

Changes in dust composition past ca. 150 yrs

Katrina Moser, Jess Mordecai, others



Changes in dust composition past ca. 150 yrs

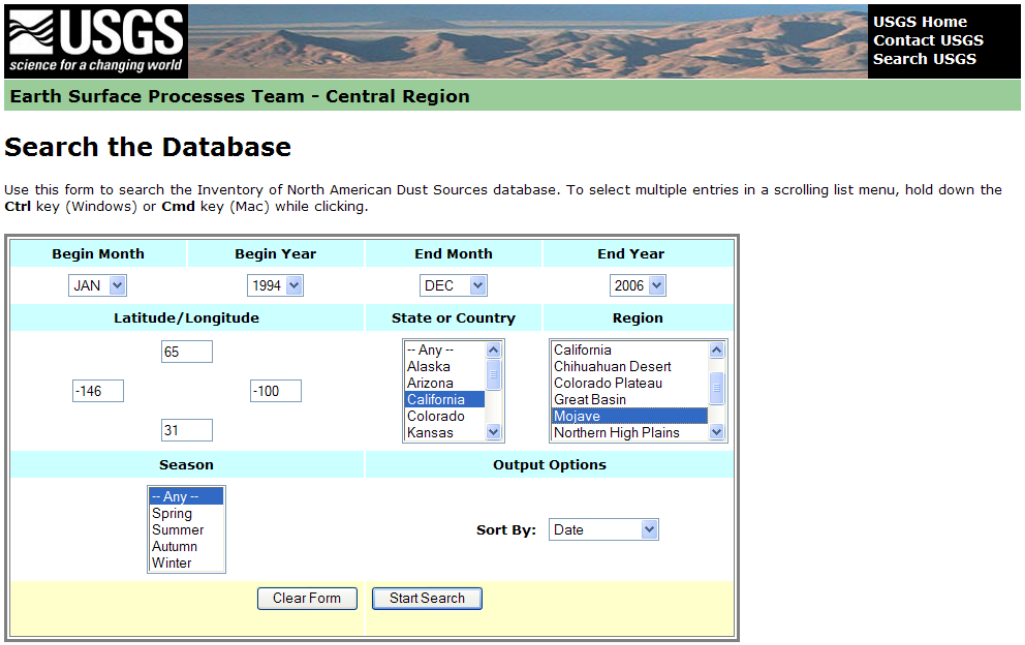


Marshall Lake, Utah

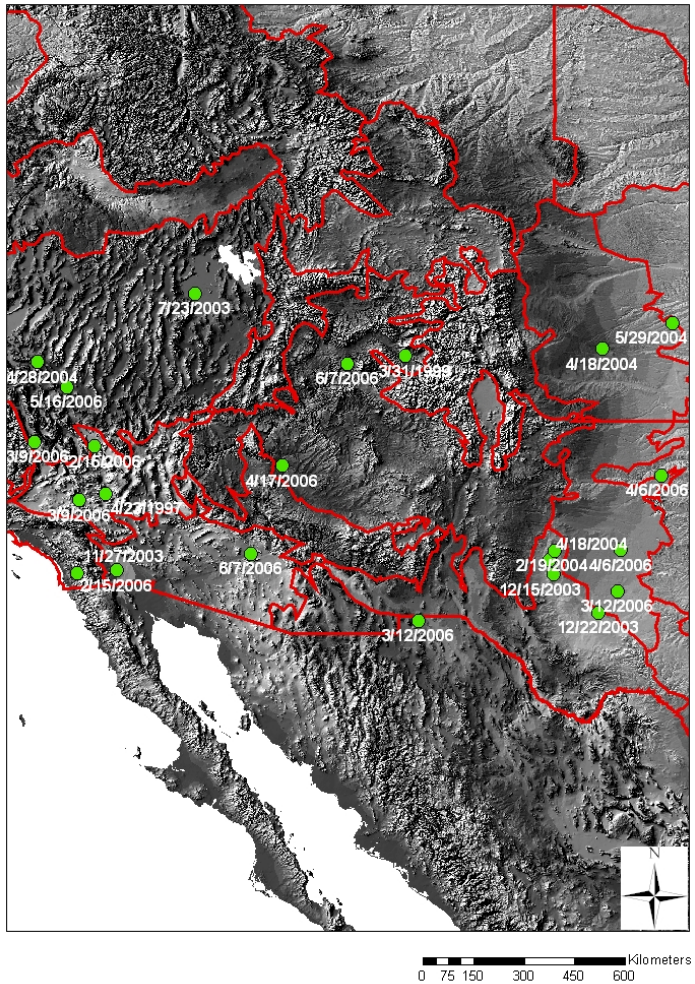
The Inventory of North American Dust Sources, Events, and Depositional Data

John-Andrew Ballantine – University of California at Santa Barbara
Richard Pelltier – U.S. Geological Survey, Denver CO
Richard Reynolds – U. S. Geological Survey, Denver CO

http://esp.cr.usgs.gov/info/dust/inventory/



Approximate locations of dust events on shaded relief of the United States



- **Understand how human activities influence dust emission from a variety of settings**
- **Compare different geomorphic sources**
- **Elucidate dust-climate relations**
- **Validation of wind-erosion models**
- **Guide detailed studies of dust sources**

The Inventory of North American Dust Sources, Events, and Depositional Data

North American Dust Sources Database Query Results

North American Dust Sources Database Query Results

4 records returned.

RECORD 1 of 4

Event Name: Mojave4_23_1997 **Date:** 1997-04-23
Region: Mojave **State:** California
Latitude: 35.08 **Longitude:** -116.04
Location: USGS

RECORD 2 of 4

Event Name: Mojave2_14&15_2006 **Date:** 2006-02-15
Region: Mojave **State:** California
Latitude: 36.35 **Longitude:** -116.35
Location: USGS

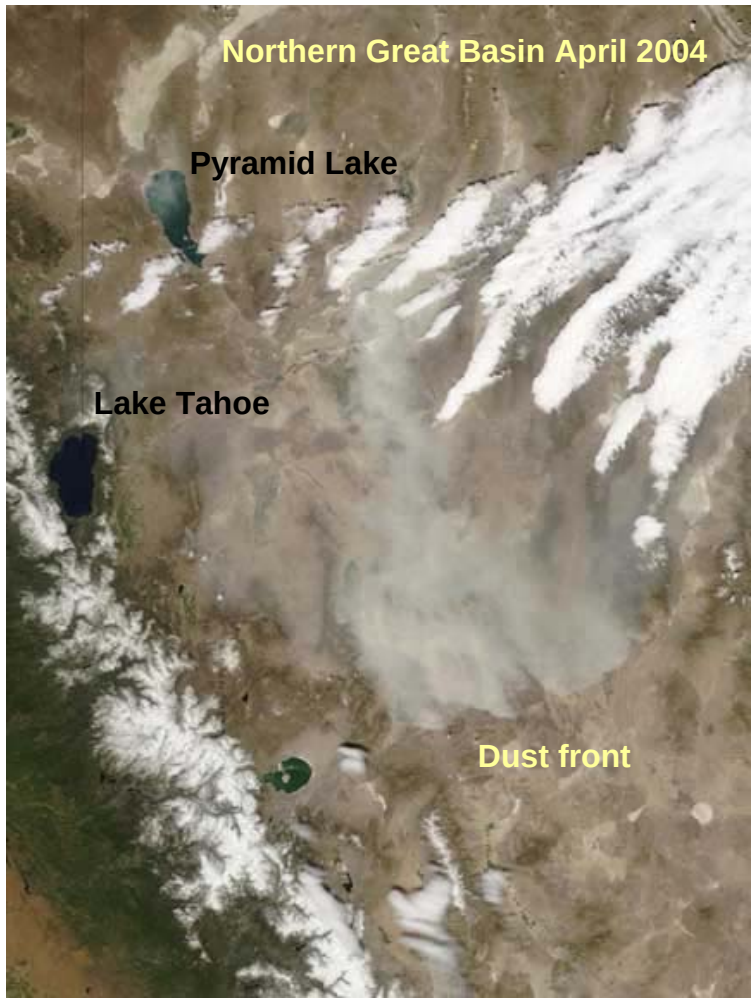
RECORD 3 of 4

Event Name: Mojave3_7-12_2006 **Date:** 2006-03-09
Region: Mojave **State:** California
Latitude: 34.89 **Longitude:** -116.70
Location: USGS and NRLM

RECORD 4 of 4

Event Name: Mojave3_7-12_2006 **Date:** 2006-03-09
Region: Mojave **State:** California
Latitude: 36.41 **Longitude:** -117.93
Location: USGS and NRLM

This web page produced by a CGI script.
For questions or comments, contact rschumann@usgs.gov



Anticipate / forecast future dust sources, loads, and composition

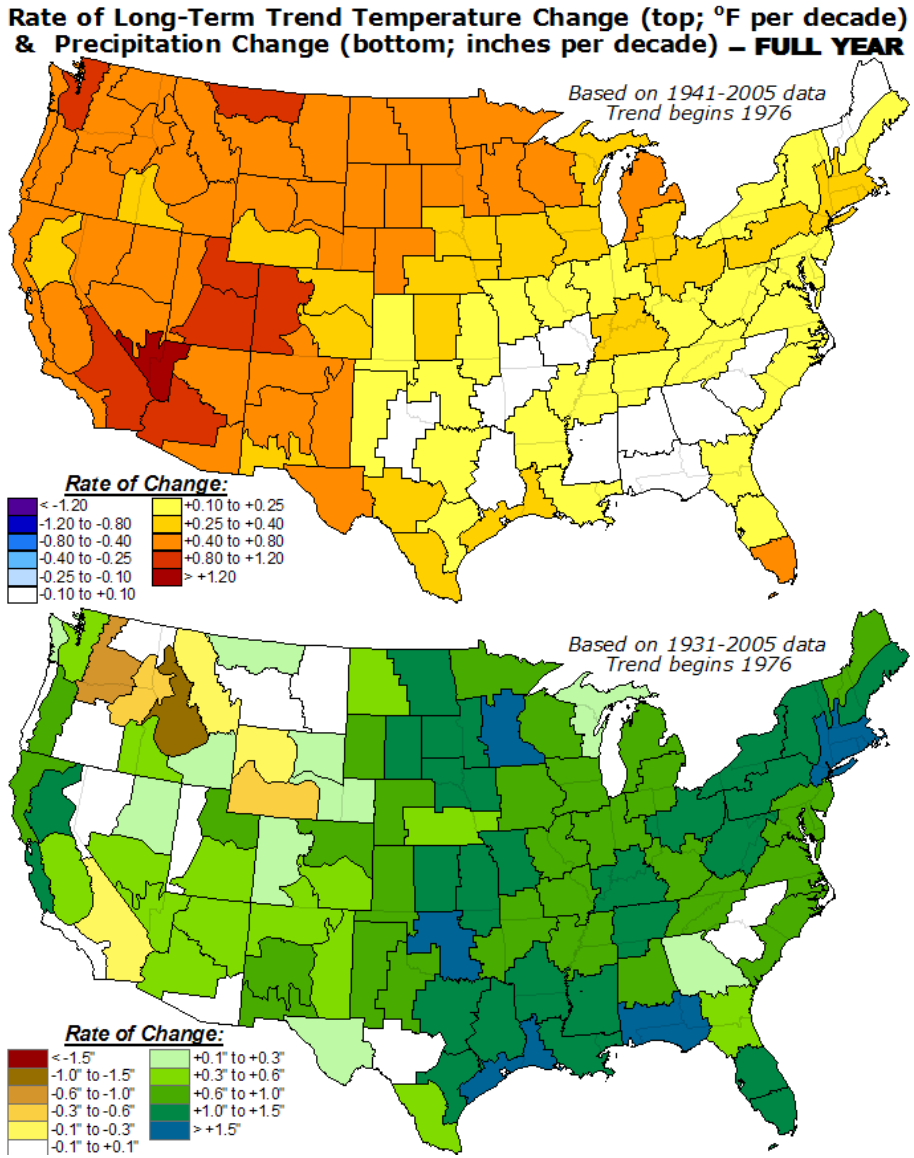
- Understand current sources, fluxes, & compositions
- Model wind erosion of complex geomorphic and ecologic surfaces
- Account for interactions among climate change (drying?) & variability (ENSO, PDO), human influences
- Drought predictions (months)

Long-Term Linear Trend Rates for Annual Precipitation in Western United States

Trends based on precipitation data from 1931-1998.

http://www.cpc.ncep.noaa.gov/trend_text.shtml#limits.

Adapted from National Weather Service, Climate Prediction Website



Interactions of Pacific Decadal Oscillation and ENSO

PDO Phase	North Pacific Sea Surface Pressure	North Pacific Sea Surface Temperature	Influence on El Niño Conditions	Influence on La Niña Conditions
Positive	Low	Cold	Enhance	Weaken
Negative	High	Warm	Weaken	Enhance

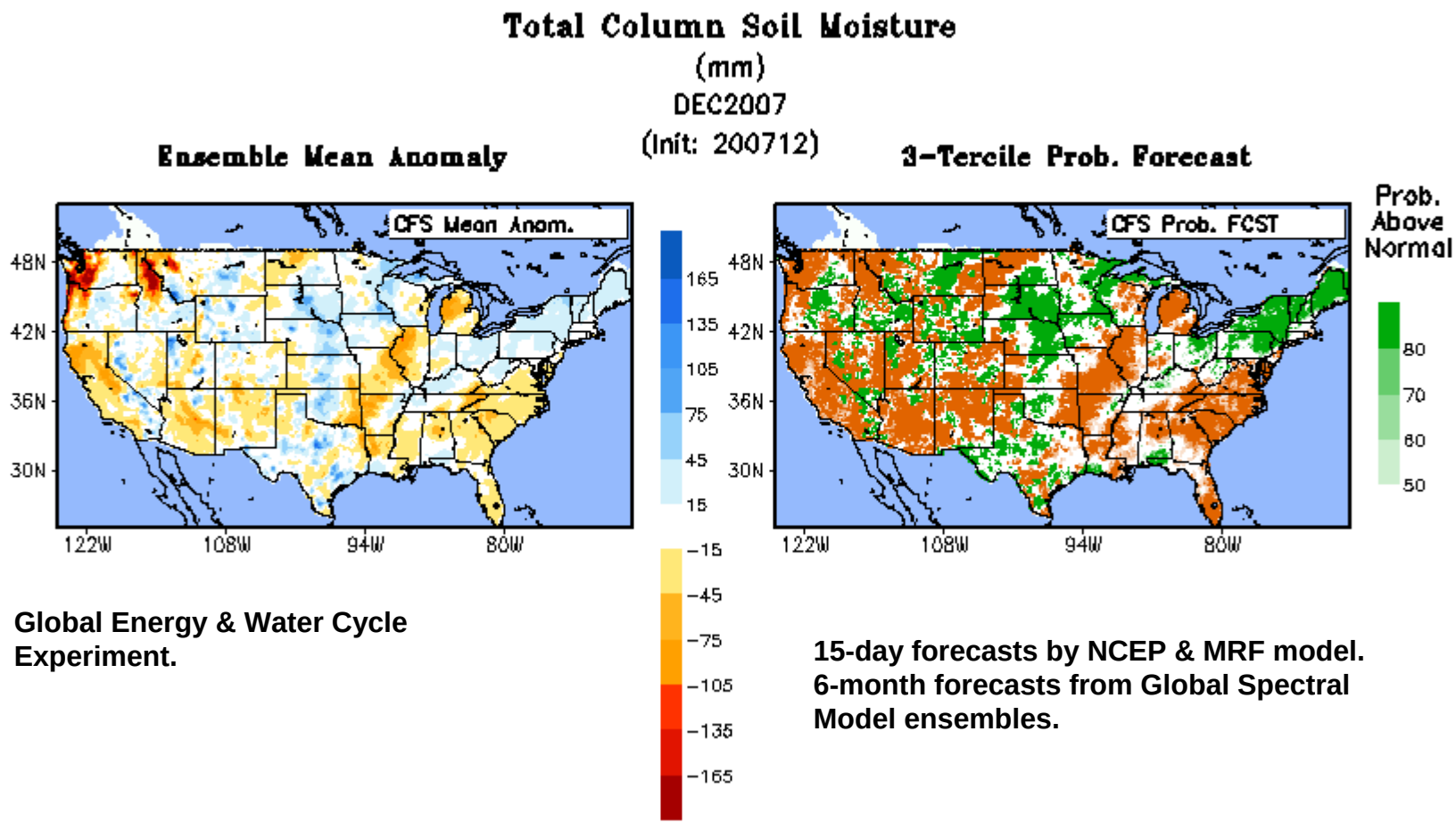
CLIMAS, Univ. of Arizona based on N. Mantua (Univ. Washington)

If conditions have shifted recently to the negative PDO phase, Southwest may experience drier La Niña winters; El Niño winters may approximate SW long-term average precipitation.

The onset of a negative PDO phase could cause the Southwest to experience generally drier conditions over the next several decades. CLIMAS.

Drought Monitoring and Hydrologic Forecasting with VIC

Change the lead time to: 3 months

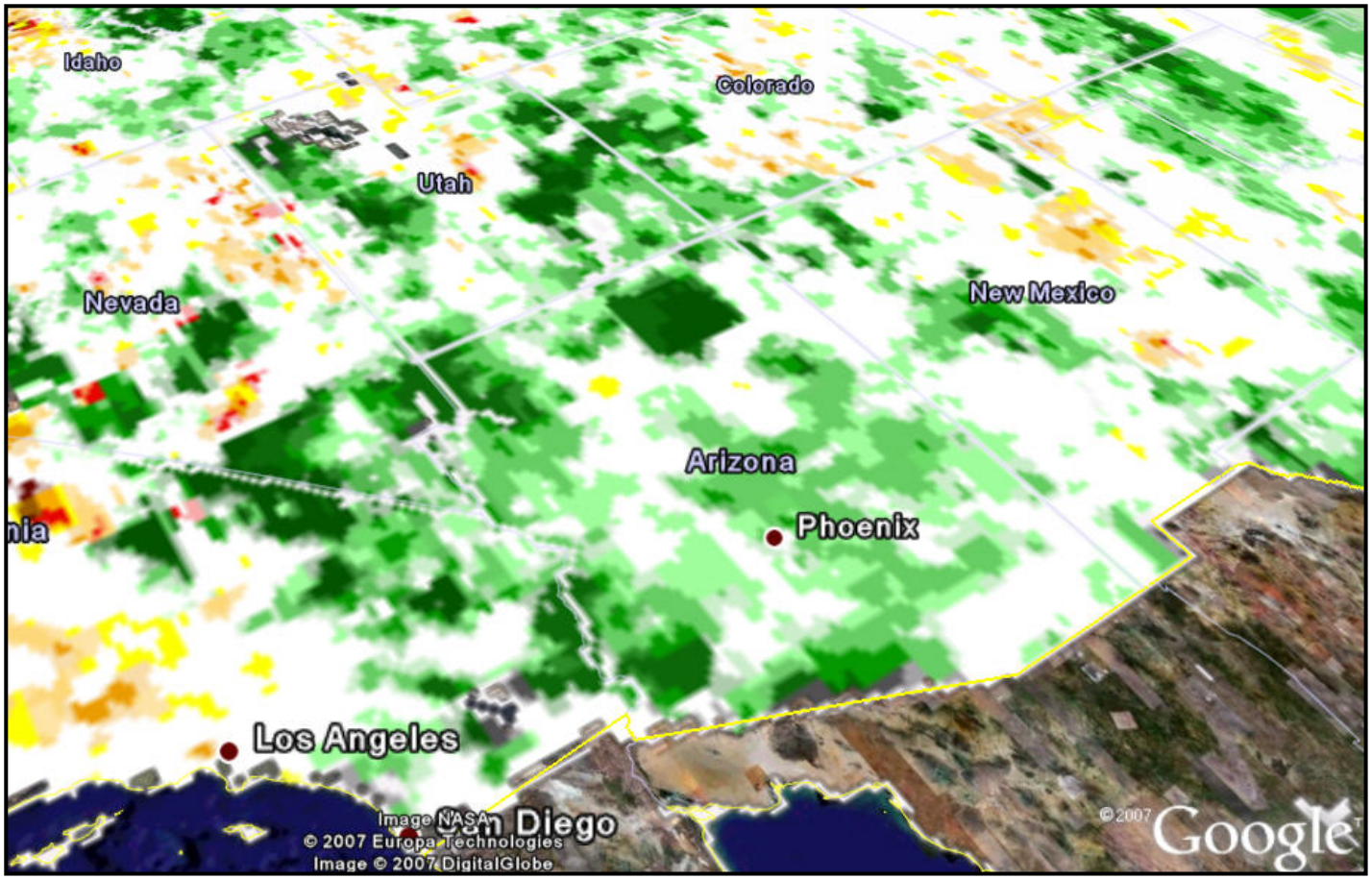


Global Energy & Water Cycle Experiment.

15-day forecasts by NCEP & MRF model. 6-month forecasts from Global Spectral Model ensembles.

http://hydrology.princeton.edu/~luo/research/FORECAST/fcst.php?id=totalsm

Drought Monitoring and Hydrologic Forecasting with VIC



http://hydrology.princeton.edu/~luo/research/FORECAST/current.php